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Attorney Docket No.	678-452 (P9148)
First Inventor or Application Identifier	Jae-Yoel Kim
Title	Apparatus and Method for Spreading....
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APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

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   - Statement Regarding Fed sponsored R & D
   - Reference to Microfiche Appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings *(if filed)*
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APPARATUS AND METHOD FOR SPREADING CHANNEL DATA IN CDMA COMMUNICATION SYSTEM USING ORTHOGONAL TRANSMIT DIVERSITY

PRIORITY

This application claims priority to an application entitled "Apparatus and Method for Spreading Channel Data in CDMA Communication System Using Orthogonal Transmit Diversity" filed in the Korean Industrial Property Office on February 4, 1999 and assigned Serial No. 99-4899, the contents of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to an apparatus and method for spreading channel data in a CDMA communication system, and in particular, to an apparatus and method for spreading channel data in a CDMA communication system using orthogonal transmit diversity (OTD).

2. Description of the Related Art

In order to increase channel capacity, a CDMA (Code Division Multiple Access) communication system spreads channels using orthogonal codes. For example, the forward link of an IMT-2000 system performs channel spreading using orthogonal codes. A reverse link can also perform channel spreading using orthogonal codes through time alignment. An example of an orthogonal code that is typically used is a Walsh code.

The number of available orthogonal codes is determined depending upon a

modulation method and a minimum data rate. However, in the proposed IMT-2000 CDMA system, the channels assigned to the users will increase in number in order to improve system performance. To this end, the future CDMA system includes a plurality of common channels and dedicated channels, and assigns the channels to the mobile stations, thereby increasing channel capacity.

However, even in the proposed IMT-2000 CDMA system, an increase in the utilization of the channels limits the number of available orthogonal codes. Further, the reduced number of available Walsh orthogonal codes limits the increase in channel capacity. In an effort to solve this problem, a method has been proposed for using quasi-orthogonal codes for channel spreading codes which have a minimum interference with the orthogonal codes and have a variable data rate.

In the IMT-2000 system, a 1x system uses a spreading code group having a spreading code rate 1, and a 3x system uses a spreading code group having a spreading code rate 3. In the 1x system, the spreading code generator stores spreading codes with a maximum length of 128 and generates a spreading code corresponding to a designated spreading code index to spread code symbols with the generated spreading code. Further, in the 3x system, the spreading code generator stores spreading codes with a maximum length of 256 and generates a spreading code corresponding to a designated spreading code index to spread code symbols with the generated spreading code.

The IMT-2000 system supports a transmit diversity, for which an orthogonal transmit diversity (ODT) scheme is typically used. Further, the IMT-2000 system can support a multicarrier system. Therefore, the IMT-2000 system can either employ or not employ orthogonal transmit diversity for the 1x direct spreading (DS) system according to circumstances. Further, for the 3x system, the IMT-2000 system can support both the multicarrier system and the direct spreading system, wherein orthogonal transmit

diversity can be either used or not used for the direct spreading system.

The orthogonal transmit diversity scheme inputs the coded symbols to first and second antennas by dividing, and then divides again the signals input to the first and second antennas into two components respectively by demultiplexing to transmit them via the different antennas. At this point, the symbol rate decreases by half, because the signals input to the first and second antennas are divided into two components by the demultiplexer. Therefore, in order to match the halved symbol rate to the total symbol rate, the divided input symbols are repeated and the pair of symbols (both the original and the repeated symbol) are orthogonally spread. One of the divided components goes to the first antenna, and the second divided component goes to the second antenna. The signal input to the first and second antennas is divided again into two components by demultiplexing, which results in a total of 4 components from the original signal. Then, the 4 components are orthogonally spread with independent orthogonal codes.

In the orthogonal transmit diversity scheme, the respective component symbols undergo repetition before orthogonal spreading. Spreading the repeated symbols with the respective spreading factors is equivalent to spreading one symbol with twice the spreading factors. The receiver then accumulates the chips for two times the spreading factor duration during spreading and multiplexes the accumulated chips. Since spreading the chips using the quasi-orthogonal codes is equivalent to spreading each component chip with twice the spreading factor in the orthogonal transmit diversity scheme, the correlation property of the quasi-orthogonal codes may vary. Actually, when using orthogonal codes of length 256, the correlation for 256 chip duration is ± 16 and $\pm 16j$. Therefore, any orthogonal transmit diversity scheme should consider the effect of spreading the chips with twice the spreading factor, when selecting the quasi-orthogonal codes for use in the spreading scheme using the quasi-orthogonal codes.

FIG. 1 shows a transmitter using an orthogonal transmit diversity scheme. Referring to FIG. 1, a channel encoder 110 encodes input data into coded symbols, and an interleaver 130 interleaves the coded symbols and provides the interleaved symbols to an adder 120. At this point, a long code generator 100 generates a long code and a decimator 105 decimates the generated long code and provides the decimated long code to the adder 120. The adder 120 adds the decimated long code and the interleaved code symbols, and a demultiplexer 140 demultiplexes the signals input from the adder 120 to the first and second antennas.

The signals demultiplexed to the first and second antennas are input to demultiplexers 150 and 155. The demultiplexer 150 demultiplexes the I-component input signal for the first antenna into I1 and Q1 components, and provides the I1 and Q1 components to symbol repeaters 160 and 162, respectively. Similarly, the demultiplexer 155 demultiplexes the Q-component input signal for the second antenna into I2 and Q2 components, and provides the I2 and Q2 components to symbol repeaters 164 and 166, respectively. The symbol repeaters 160 and 162 repeat their input signal I1 and Q1 two times, respectively. The symbol repeater 164 outputs the I2 signal once and then outputs an inverted input signal. Similarly, the symbol repeater 166 outputs the Q2 signal once and then outputs an inverted input signal. In order to maintain the orthogonality between the first and second antenna signals demultiplexed by the demultiplexer 140, the symbol repeaters 160 and 162 repeat the input symbols in the different manner from the symbol repeaters 164 and 166. Although the symbol repeaters 160 and 162 have a similar operation to the existing symbol repetition, the symbol repeaters 164 and 166 repeat the input symbols in different manner. For example, upon receipt of an input signal '1', the repeaters 164 and 166 output a symbol '1' and an inverted symbol '-1'.

Thereafter, a spreader 170 receives the signals output from the symbol repeaters 160 and 162, and at the same time, a spreading code generator 180 generates a spreading

code corresponding to an input spreading code index k1 and provides the generated spreading code to the spreader 170. The spreader 170 then spreads the signals output from the symbol repeaters 160 and 162 with the spreading code. Further, a spreader 175 receives the signals output from the symbol repeaters 164 and 166, and at the same time, a spreading code generator 185 generates a spreading code corresponding to an input spreading code index k2 and provides the generated spreading code to the spreader 175. The spreader 175 then spreads the signals output from the symbol repeaters 164 and 166 with the spreading code.

FIG. 2 shows a receiver using orthogonal transmit diversity. Referring to FIG. 2, a despreader 270 receives input data rI1 and rQ1, and at the same time, a spreading code generator 280 generates the spreading code corresponding to an input spreading code index k1 and provides the generated spreading code to the despreader 270. The despreader 270 then despreads the input data rI1 and rQ1 using the spreading code provided from the spreading code generator 280 and provides the despread signals to a multiplexer 250. Similarly, a despreader 275 receives input data rI2 and rQ2, and at the same time, a spreading code generator 285 generates the spreading code corresponding to an input spreading code index k2 and provides the generated spreading code to the despreader 275. The despreader 275 then despreads the input data rI2 and rQ2 using the spreading code provided from the spreading code generator 285 and provides the despread signals to a multiplexer 255.

The multiplexer 250 multiplexes the signals output from the despreader 270 to output a first antenna component, and the multiplexer 255 multiplexes the signals output from the despreader 275 to output a second antenna component. A multiplexer 240 multiplexes the first and second antenna components and provides the multiplexed signals to an adder 220. At the same time, a long code generator 200 generates a long code and a decimator 205 decimates the long code and provides the decimated long code

to the adder 220. The adder 220 then adds the decimated long code and the codes output from the multiplexer 240, and a deinterleaver 230 deinterleaves the signals output from the adder 220. A channel decoder 210 decodes the signals output from the deinterleaver 230.

FIG. 3 shows a direct spreading scheme which does not use orthogonal transmit diversity. Referring to FIG. 3, a channel encoder 310 encodes input data into coded symbols, and an interleaver 330 interleaves the coded symbols and provides the interleaved symbols to an adder 320. At the same time, a long code generator 300 generates a long code and a decimator 305 decimates the long code and provides the decimated long code to the adder 320. The adder 320 then adds the decimated long code and the interleaved code symbols, and provides its outputs to a demultiplexer 340. The demultiplexer 340 demultiplexes the input signals into an I-component signal and a Q-component signal. A spreader 370 receives the I-component and Q-component signals, and at the same time, a spreading code generator 380 generates a spreading code corresponding to an input spreading code index k and provides the generated spreading code to the spreader 370. The spreader 370 then spreads the I-component and Q-component signals output from the demultiplexer 340 with the spreading code.

FIG. 4 shows a receiver which does not use orthogonal transmit diversity. Referring to FIG. 4, a despreader 470 receives input data I and Q, and at the same time, a spreading code generator 480 provides the despreader 470 with a spreading code corresponding to an input spreading code index k. The despreader 470 despreads the input data I and Q using the spreading code provided from the spreading code generator 480, and provides the despread signals to a multiplexer 440. The multiplexer 440 multiplexes the despread I and Q components, and provides the multiplexed signals to an adder 420. At this point, a long code generator 400 generates a long code, and a decimator 405 decimates the long code and provides the decimated long code to the adder

420. The adder 420 adds the decimated long code and the codes output from the multiplexer 440, and provides its output signals to a deinterleaver 430. The deinterleaver 430 deinterleaves the input signals and a channel decoder 410 decodes the deinterleaved signals.

The IMT-2000 system having the above spreading scheme supports a multicarrier system. The multicarrier mobile communication system transmits signals at one carrier of a 1.25MHz band for the 1x system, and transmits the signals at three carriers for 3x system. The respective carriers are assigned independent orthogonal codes. When the 1x system is overlaid with the 3x system, using orthogonal codes of different lengths will cause interference between the systems. Herein, it will be assumed that the 1x system generates a quasi-orthogonal code using a mask function of length 128, and the 3x system generates a quasi-orthogonal code using a mask function of length 256. In this case, since a good correlation property is not guaranteed between a spreading code of length 128 which uses a mask function at a spreading rate 1 and a spreading code of length 128 which uses a mask function at a spreading rate 3 at each 1.25MHz band, increased interference may occur between a user using a mask function at the spreading rate 1 and a user using a mask function at the spreading rate 3.

When the 1x system uses the quasi-orthogonal code and the 3x system uses the orthogonal code, interference that the quasi-orthogonal code ($QOF_m + W_k$) user of the 1x system, experiences from the orthogonal code (W_j) user of the 3x system can be given by the equation:

$$\sum_{i}^{T_i}\left[(QOF_{m,i}+W_{k,i})+W_{j,i}\right]=\sum_{i}^{T_i}\left[QOF_{m,i}+(W_{k,i}+W_{j,i})\right]=\sum_{i}^{T_i}\left[QOF_{m,i}+W_{s,i}\right]<\Theta_{\min} \quad \cdots (1)$$

That is, the interference satisfies an upper limit formula of the correlation for the

quasi-orthogonal code. Therefore, in this case, this is not a serious matter. However, when the 1x system and 3x system both use the quasi-orthogonal code, interference that the quasi-orthogonal code (QOF_m+W_k) user of the 1x system experiences from the quasi-orthogonal code (QOF_n+W_j) user of the 3x system does not satisfy the upper limit formula, as shown in Equation (2) below:

$$\sum_{i}^{T_i}\left[(QOF_{m,i}+W_{k,i})+(QOF_{n,i}+W_{j,i})\right]=\sum_{i}^{T_i}\left[(QOF_{m,i}+W_{k,i})+(QOF_{n,i}+W_{j,i})\right]$$

$$=\sum_{i}^{T_i}\left[(QOF_{m,i}+QOF_{n,i})+W_{s,i}\right] \quad \cdots\cdots (2)$$

In this case, the mutual interference between the channels increases.

Therefore, when using the quasi-orthogonal codes of spreading code groups having different lengths, the mobile communication system stores the spreading codes of different lengths, and thus increases the hardware complexity. Further, using the spreading codes having different spreading rates in the overlay scheme deteriorates the interference property between two users thereby causing performance degradation.

FIG. 5 shows a transmitter for a 3x multicarrier system. Referring to FIG. 5, a channel encoder 500 encodes an input signal into coded symbols, and an interleaver 505 interleaves the coded symbols. A long code spreader 510 spreads the interleaved symbols with a long code output from a long code generator 515. A demultiplexer 580 demultiplexes the spread signals into three components, each of which is divided again into I component and Q component, and provides the I and Q components to spreaders 520, 522 and 524.

When the spreader 520 receives the signals from the demultiplexer 580, a

spreading code generator 540 generates a spreading code of length 256 corresponding to an input spreading code index k indicating a channel assigned to the user, and provides the generated spreading code to the spreader 520. The spreader 520 spreads the long code spread signals at a chip rate of 1.2288Mcps by operating each symbol of the input signal with a specified number of chips ($256/2^n$, $0 \leq n \leq 6$) of the spreading code. When the spread signals are input to a PN spreader 530, a short PN code generator 550 generates a short PN code and outputs the generated short PN code at a chip rate of 1.2288Mcps. The PN spreader 530 PN spreads the input signals with the PN codes output from the short PN code generator 550. Since the other spreaders and spreading code generators have the same operation, a detailed description will not be given in order to avoid duplication.

FIG. 6 shows a receiver for the 3x multicarrier system. Referring to FIG. 6, when the spread signals are input to a PN despreader 630, a short PN code generator 650 generates a short PN code and outputs the generated short PN code at a chip rate of 1.2288Mcps. The PN despreader 630 operates the input signals and the short PN code on a chip unit basis to output PN despread signals.

When the PN despread signals are input to a despreader 620, a spreading code generator 640 generates a spreading code of a maximum length 256 corresponding to an input spreading code index k indicating a channel assigned to the user, and provides the generated spreading code to the despreader 620. The despreader 620 then operates on each symbol of the PN despread signal with a specified number of chips ($256/2^n$, $0 \leq n \leq 6$) of the spreading code, and accumulates the signals. The despread signals from the despreader 620 are provided to a multiplexer 680. In the same manner, the signals input to PN despreaders 632 and 634 are provided to the multiplexer 680 after despreading. The multiplexer 680 then multiplexes the input signals despread through three different paths in the reverse order of signal demultiplexing performed in the transmitter. When the multiplexed signals are input to a long code despreader 610, a long code generator 615

generates a long code. The long code despreader 610 despreads the multiplexed signals with the long code output from the long code generator 615. A deinterleaver 605 deinterleaves the long code despread signals and a channel decoder 600 decodes the deinterleaved signals.

In the CDMA communication system using orthogonal transmit diversity, even though the same symbol is repeated two times when spreading the signals transmitted to the respective antennas, it is undesirably necessary to spread the symbols using the orthogonal codes according to the spreading rates of the respective symbols.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a device and method for spreading a transmission signal with a spreading code having at least two times a spreading factor in a chip spreading rate in a CDMA communication system using orthogonal transmit diversity.

It is another object of the present invention to provide a device and method for enabling two users having different spreading rates to spread transmission signals using spreading codes of the same length in a CDMA communication system.

To achieve the above objects, there is provided a channel spreading method in a CDMA communication system which spreads a pair of symbols obtained by repeating one symbol with a quasi-orthogonal code having a given length to transmit the spread symbols through a first antenna and spreads said symbol and an inverted symbol of said symbol with said quasi-orthogonal code to transmit the spread symbols through a second antenna. The method comprises spreading one of said pair of symbols with a portion of said quasi-orthogonal code and spreading another symbol of said pair of symbols with a

remaining portion of said quasi-orthogonal code; and spreading said symbol with a portion of said quasi-orthogonal code and spreading said inverted symbol with the remaining portion of said quasi-orthogonal code.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a diagram illustrating a transmitter using an orthogonal transmit diversity in a mobile communication system;

FIG. 2 is a diagram illustrating a receiver using orthogonal transmit diversity in a mobile communication system;

FIG. 3 is a diagram illustrating a transmitter not using orthogonal transmit diversity in a mobile communication system;

FIG. 4 is a diagram illustrating a receiver not using orthogonal transmit diversity in a mobile communication system;

FIG. 5 is a diagram illustrating a transmitter in a 3x multicarrier mobile communication system;

FIG. 6 is a diagram illustrating a receiver in a 3x multicarrier mobile communication system;

FIG. 7 is a diagram illustrating a spreading scheme for the transmitter and receiver in a mobile communication system according to an embodiment of the present invention;

FIG. 8 is a diagram illustrating a rotator in the spreading scheme of FIG. 7 for the transmitter according to an embodiment of the present invention;

FIG. 9 is a diagram illustrating a rotator in the despreading scheme of FIG. 7 for the receiver according to an embodiment of the present invention;

FIG. 10A is a timing diagram explaining the operation of a spreader in a 1x direct spreading system not using orthogonal transmit diversity according to a first embodiment of the present invention;

FIG. 10B is a timing diagram explaining the operation of a spreader at a first antenna in a 1x direct spreading system using orthogonal transmit diversity according to a first embodiment of the present invention;

FIG. 10C is a timing diagram explaining the operation of a spreader at a second antenna in the 1x direct spreading system using orthogonal transmit diversity according to a first embodiment of the present invention;

FIG. 10D is a timing diagram explaining the operation of a spreader in a 3x direct spreading system not using orthogonal transmit diversity according to a first embodiment of a present invention;

FIG. 10E is a timing diagram explaining the operation of a spreader at a first antenna in the 3x direct spreading system using orthogonal transmit diversity according to a first embodiment of the present invention;

FIG. 10F is a timing diagram explaining the operation of a spreader at a second antenna in the 3x direct spreading system using orthogonal transmit diversity according to a first embodiment of the present invention;

FIG. 10G is a timing diagram explaining the operation of a spreader in a 3x multicarrier system using orthogonal transmit diversity according to a first embodiment of the present invention;

FIG. 11A is a timing diagram explaining the operation of a spreader in the 1x direct spreading system not using orthogonal transmit diversity according to a second embodiment of the present invention;

FIG. 11B is a timing diagram explaining the operation of a spreader at a first antenna in the 1x direct spreading system using orthogonal transmit diversity according to a second embodiment of the present invention;

FIG. 11C is a timing diagram explaining the operation of a spreader at a second

antenna in the 1x direct spreading system using orthogonal transmit diversity according to a second embodiment of the present invention;

FIG. 11D is a timing diagram explaining the operation of a spreader in the 3x direct spreading system not using orthogonal transmit diversity according to a second embodiment of the present invention;

FIG. 11E is a timing diagram explaining the operation of a spreader at a first antenna in the 3x direct spreading system using orthogonal transmit diversity according to a second embodiment of the present invention;

FIG. 11F is a timing diagram explaining the operation of a spreader at a second antenna in the 3x direct spreading system using orthogonal transmit diversity according to a second embodiment of the present invention;

FIG. 11G is a timing diagram explaining the operation of a spreader in the 3x multicarrier system using orthogonal transmit diversity according to a second embodiment of the present invention;

FIG. 12A is a timing diagram explaining the operation of a spreader in the 1x direct spreading system not using orthogonal transmit diversity according to a third embodiment of the present invention;

FIG. 12B is a timing diagram explaining the operation of a spreader at a first antenna in the 1x direct spreading system using orthogonal transmit diversity according to a third embodiment of the present invention;

FIG. 12C is a timing diagram explaining the operation of a spreader at a second antenna in the 1x direct spreading system using orthogonal transmit diversity according to a third embodiment of the present invention;

FIG. 12D is a timing diagram explaining the operation of a spreader in the 3x direct spreading system not using orthogonal transmit diversity according to a third embodiment of the present invention;

FIG. 12E is a timing diagram explaining the operation of a spreader at a first antenna in the 3x direct spreading system using orthogonal transmit diversity according

to a third embodiment of the present invention;

FIG. 12F is a timing diagram explaining the operation of a spreader at a second antenna in the 3x direct spreading system using orthogonal transmit diversity according to a third embodiment of the present invention; and

FIG. 12G is a timing diagram explaining the operation of a spreader in the 3x multicarrier system using orthogonal transmit diversity according to a third embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will be described herein below with reference to the accompanying drawings. In the following description, well-known functions or constructions are not described in detail since they would obscure the invention in unnecessary detail.

The term "orthogonal spreading" as used herein has the same meaning as the term "channel spreading". Further, the term "spreading codes of the same length" means quasi-orthogonal code sets having the same length.

In an exemplary embodiment of the present invention, a description will be made of spreading and despreading operation of the IMT-2000 base station and mobile station, wherein the 1x system and the 3x system use spreading codes of the same length. It is also possible to apply the invention to the systems using the spreading codes of different lengths.

A description has already been made of the spreader in the transmitter and receiver of FIGS. 1 to 6. The spreaders for the transmitter and the receiver are identical except for the operation of a rotator therein.

FIG. 7 shows a spreader for a CDMA communication system according to an embodiment of the present invention. Herein, the quasi-orthogonal code is a code generated by mixing a Walsh orthogonal code and a QOF mask, wherein the QOF mask is comprised of a sign code QOF_{sign} and phase code QOF_{rot}. Further, the phase code has the same value as a specific Walsh orthogonal code.

Referring to FIG. 7, when adders 710 and 715 receive I and Q signals, an adder 700 adds a first Walsh code Walsh1 and a sign component QOF_{sign} and provides its output to the adders 710 and 715. Here, the first Walsh code Walsh1 is a Walsh code for generating the quasi-orthogonal code. The adder 710 adds the input signal I and the output signal of the adder 700 and provides its output to a rotator 720, and the adder 715 adds the input signal Q and the output signal of the adder 700 and provides its output to the rotator 720. The rotator 720 then rotates the signals input from the adders 710 and 715 according to QOF_{rot}. Here, QOF_{rot} is used to control a phase of the spread signal.

FIG. 8 shows the rotator 720 in the spreader of FIG. 7 for the transmitter. Referring to FIG. 8, the signal output from the adder 710 is input to a D1 node of a selector 800 and a D2 node of a selector 810, and the signal output from the adder 715 is input to an inverter 820 and a D1 node of the selector 810. The inverter 820 inverts the input signal by multiplying it by '-1' and provides the inverted signal to a D2 node of the selector 800. The selectors 800 and 810 output the signals received at their D1 nodes when the QOF_{rot} is '0', and otherwise, output the signals received at their D2 nodes.

FIG. 9 shows the rotator 720 in the despreader of FIG. 7 for the receiver. Referring to FIG. 9, the signal output from the adder 710 is input to a D1 node of a selector 900 and an inverter 920. The inverter 920 inverts the input signal by multiplying it by '-1' and provides the inverted signal to a D2 node of a selector 910. The signal output from the adder 715 is input to a D2 node of the selector 900 and a D1 node of the

selector 910. The selectors 900 and 910 output the signals received at their D1 nodes when QOF_{rot} is '0', and otherwise, output the signals received at their D2 nodes.

In the embodiments of the present invention, the quasi-orthogonal sequence mask function of length 128 and the quasi-orthogonal sequence of length 256 are used, which are disclosed in Korean patent application Nos. 99-888 and 99-1339. The quasi-orthogonal sequence mask function of length 128 and the quasi-orthogonal sequence of length 256 should have (1) a good full correlation property with the Walsh orthogonal code, (2) a good full correlation property between quasi-orthogonal codes, and (3) a good full partial correlation property with the Walsh orthogonal code. In addition, they should have a good partial correlation property between the quasi-orthogonal codes. The invention also provides quasi-orthogonal codes of length 128 and quasi-orthogonal codes of length 256 that satisfy the above conditions.

In the embodiments below, the orthogonal transmit diversity scheme uses the quasi-orthogonal sequences. Further, the multicarrier system also uses the quasi-orthogonal sequences. In the various embodiments below, the overall system operation is similar except the spreader. Further, since only the process for processing the spreading codes of different lengths is varied, the description of the invention will be made with reference to the timing diagrams for the symbols in the rotator 720 of FIG. 7.

A. First Embodiment

In the first embodiment, the 1x direct spreading system uses quasi-orthogonal sequences of length 128, the 3x direct spreading system uses quasi-orthogonal sequences of length 256, and the 3x multicarrier system uses quasi-orthogonal sequences of length 256.

A description will be made of spreading operation in the 1x direct spreading system not using orthogonal transmit diversity (or 1x non-OTD direct spreading system), with reference to FIGS. 7 and 10A. The 1x direct spreading system not using orthogonal transmit diversity uses the spreading codes of length 128, shown in FIG. 10A, output from the rotator 720 of FIG. 7. In FIG. 7, when the I and Q component symbols are input to the adders 710 and 715, the adder 700 adds a Walsh code of length 128 and a sign component QOF_{sign} of a quasi-orthogonal sequence of length 128 as shown in FIG. 10A, and provides its output to the adders 710 and 715. The adders 710 and 715 add the I and Q component input symbols, respectively, and the output of the adder 700, and provide their output signals to the rotator 720. The rotator 720 rotates the 128-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 128. Referring to FIG. 10A, one input symbol is added to the Walsh orthogonal code of length 128 and the sign component QOF_{sign} of the quasi-orthogonal code of length 128, and then rotated according to the phase component QOF_{rot} of the quasi-orthogonal code of length 128.

Next, a description will be made of spreading operation in the 1x direct spreading system using orthogonal transmit diversity (or 1x OTD direct spreading system), with reference to FIGS. 7, 10B and 10C, wherein FIGS. 10B and 10C show the timing diagrams for the first and second antennas, respectively.

In the first embodiment, the 1x direct spreading system using orthogonal transmit diversity uses the spreading code of length 128, and with regard to the first antenna, the spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 10B. When the first I and Q component symbols out of the symbols repeated by the symbol repeaters 160 and 162 of FIG. 1 are input to the adders 710 and 715 of FIG. 7, the adder 700 adds a Walsh code of length 128 and a sign component QOF_{sign} of a quasi-orthogonal sequence of length 128 as shown in FIG. 10B, and provides its output to the adders 710 and 715.

The adders 710 and 715 add the I and Q component input symbols, respectively, and the output of the adder 700, and provide their output signals to the rotator 720. The rotator 720 then rotates the 128-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 128.

When the second I and Q component symbols out of the symbols repeated by the symbol repeaters 160 and 162 of FIG. 1 are input to the adders 710 and 715 of FIG. 7, the adder 700 adds a Walsh code of length 128 and a sign component QOF_{sign} of a quasi-orthogonal sequence of length 128 as shown in FIG. 10B, and provides its output to the adders 710 and 715. The adders 710 and 715 add the I and Q component input symbols, respectively, and the output of the adder 700, and provide their output signals to the rotator 720. The rotator 720 then rotates the 128-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 128. Referring to FIG. 10B, the first input symbol is added to the Walsh orthogonal code of length 128 and the sign component QOF_{sign} of the quasi-orthogonal code of length 128, and then rotated according to the phase component QOF_{rot} of the quasi-orthogonal code of length 128. Subsequently, in the same manner, the second input symbol is added to the Walsh orthogonal code of length 128 and the sign component QOF_{sign} of the quasi-orthogonal code of length 128, and then rotated according to the phase component QOF_{rot} of the quasi-orthogonal code of length 128.

With regard to the second antenna, the spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 10C. When the first I and Q component symbols out of the symbols repeated by the symbol repeaters 164 and 166 of FIG. 1 are input to the adders 710 and 715 of FIG. 7, the adder 700 adds a Walsh code of length 128 and a sign component QOF_{sign} of a quasi-orthogonal sequence of length 128 as shown in FIG. 10C, and provides its output to the adders 710 and 715. The adders 710 and 715 then add the I and Q component input symbols, respectively, and the output of the adder 700, and

provide their output signals to the rotator 720. The rotator 720 then rotates the 128-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 128.

The second I and Q component symbols out of the symbols repeated by the symbol repeaters 164 and 166 are the inverted symbols obtained by multiplying the first symbols by '-1'. When inverted symbols are input to the adders 710 and 715 of FIG. 7, the adder 700 adds a Walsh code of length 128 and a sign component QOF_{sign} of a quasi-orthogonal sequence of length 128 as shown in FIG. 10C, and provides its output to the adders 710 and 715. The adders 710 and 715 then add the I and Q component input symbols, respectively, and the output of the adder 700, and provide their output signals to the rotator 720. The rotator 720 then rotates the 128-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 128.

Referring to FIG. 10C, the first input symbol out of the symbols repeated by the symbol repeaters 160 and 162 is added to the Walsh orthogonal code of length 128 and the sign component QOF_{sign} of the quasi-orthogonal code of length 128, and then rotated according to the phase component QOF_{rot} of the quasi-orthogonal code of length 128. Subsequently, in the same manner, the second input symbol obtained by inverting the first symbol is added to the Walsh orthogonal code of length 128 and the sign component QOF_{sign} of the quasi-orthogonal code of length 128, and then rotated according to the phase component QOF_{rot} of the quasi-orthogonal code of length 128.

A description will now be made of spreading operation in the 3x direct spreading system not using orthogonal transmit diversity, with reference to FIGS. 7 and 10D. The 3x direct spreading system not using orthogonal transmit diversity uses spreading codes of length 256, shown in FIG. 10D, output from the rotator 720 of FIG. 7. In FIG. 7, when the I and Q component symbols are input to the adders 710 and 715, the adder 700 adds a

Walsh code of length 256 and a sign component QOF_{sign} of a quasi-orthogonal sequence of length 256 as shown in FIG. 10D, and provides its output to the adders 710 and 715. The adders 710 and 715 then add the I and Q component input symbols, respectively, and the output of the adder 700, and provide its output signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 256. Referring to FIG. 10D, one input symbol is added to the Walsh orthogonal code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the phase component QOF_{rot} of the quasi-orthogonal code of length 256.

Next, a description will be made of spreading operation in the 3x direct spreading system using orthogonal transmit diversity, with reference to FIGS. 7, 10E and 10F, wherein FIGS. 10E and 10F show the timing diagrams for the first and second antennas, respectively.

In the first embodiment, the 3x direct spreading system using orthogonal transmit diversity uses the spreading code of length 256, and, with regard to the first antenna, the spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 10E. When the first I and Q component symbols out of the symbols repeated by the symbol repeaters 160 and 162 of FIG. 1 are input to the adders 710 and 715 of FIG. 7, the adder 700 adds a Walsh code of length 256 and a sign component QOF_{sign} of a quasi-orthogonal sequence of length 256 as shown in FIG. 10E, and provides its output to the adders 710 and 715. The adders 710 and 715 add the I and Q component input symbols and the output of the adder 700, and provide their output signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 256.

When the second I and Q component symbols out of the symbols repeated by the

symbol repeaters 160 and 162 of FIG. 1 are input to the adders 710 and 715 of FIG. 7, the adder 700 adds a Walsh code of length 256 and a sign component QOF_{sign} of a quasi-orthogonal sequence of length 256 as shown in FIG. 10E, and provides its output to the adders 710 and 715. The adders 710 and 715 add the I and Q component input symbols and the output of the adder 700, and provide their output signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 256. Referring to FIG. 10E, the first input symbol is added to the Walsh orthogonal code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the phase component QOF_{rot} of the quasi-orthogonal code of length 256. Subsequently, in the same manner, the second input symbol is added to the Walsh orthogonal code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the phase component QOF_{rot} of the quasi-orthogonal code of length 256.

With regard to the second antenna, the spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 10F. When the first I and Q component symbols out of the symbols repeated by the symbol repeaters 164 and 166 of FIG. 1 are input to the adders 710 and 715 of FIG. 7, the adder 700 adds a Walsh code of length 256 and a sign component QOF_{sign} of a quasi-orthogonal sequence of length 256 as shown in FIG. 10F, and provides its output to the adders 710 and 715. The adders 710 and 715 add the I and Q component input symbols and the output of the adder 700, and provide their output signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 256.

The second I and Q component symbols out of the symbols repeated by the symbol repeaters 164 and 166 are the inverted symbols obtained by multiplying the first

symbols by '-1'. When inverted symbols are input to the adders 710 and 715 of FIG. 7, the adder 700 adds a Walsh code of length 256 and a sign component QOF_{sign} of a quasi-orthogonal sequence of length 256 as shown in FIG. 10F, and provides its output to the adders 710 and 715. The adders 710 and 715 add the I and Q component input symbols and the output of the adder 700, and provide their output signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 256.

Referring to FIG. 10F, the first input symbol is added to the Walsh orthogonal code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the phase component QOF_{rot} of the quasi-orthogonal code of length 256. Subsequently, in the same manner, the inverted symbol obtained by inverting the first symbol is added to the Walsh orthogonal code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the phase component QOF_{rot} of the quasi-orthogonal code of length 256.

A description will now be made of spreading operation in the 3x multicarrier system with reference to FIGS. 7 and 10G. In the 3x multicarrier system according to the first embodiment, the spreader uses the spreading codes of length 256 for all three carriers, and the spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 10G.

In FIG. 7, when the I and Q component symbols are input to the adders 710 and 715, the adder 700 adds the Walsh code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, and provides its output to the adders 710 and 715. Then, the adders 710 and 715 add the I and Q component symbols, respectively, and the output of the adder 700, and provide their outputs to the rotator 720. The rotator

720 then rotates the 256-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 256. Referring to FIG. 10G, one input symbol is added to the Walsh code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the phase component QOF_{rot} of the quasi-orthogonal code of length 256.

B. Second Embodiment

In the second embodiment, the 1x direct spreading system uses the quasi-orthogonal codes of length 256, the 3x direct spreading system uses the quasi-orthogonal codes of length 256, and the 3x multicarrier system uses the quasi-orthogonal codes of length 256.

First, a description will be made of spreading operation in the 1x direct spreading system not using orthogonal transmit diversity, with reference to FIGS. 7 and 11A. The 1x non-OTD direct spreading system according to the second embodiment uses quasi-orthogonal spreading codes of length 256, and the spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 11A.

In FIG. 7, when the I and Q component symbols are input to the adders 710 and 715, the adder 700 adds the Walsh code of length 128 and the leading 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 11A, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 128-chip input signals according to the leading 128-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 256. After this process, when the next I and Q component symbols are input to the adders 710 and 715, the adder 700 adds the Walsh

code of length 128 and the following 128- chip portion of the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 11A, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 128-chip input signals according to the following 128-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 256.

Referring to FIG. 11A, one input symbol is added to the leading 128-chip portion of the Walsh code of length 128 and the leading 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the leading 128-chip portion of the phase component QOF_{rot} of the quasi-orthogonal code of length 256. Subsequently, the next input symbol is added to the Walsh code of length 128 and the following 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the following 128-chip portion of the phase component QOF_{rot} of the quasi-orthogonal code of length 256.

Next, a description will be made of spreading operation in the 1x OTD direct spreading system, with reference to FIGS. 7, 11B and 11C, wherein FIG. 11B shows a timing diagram for the first antenna and FIG. 11C shows a timing diagram for the second antenna. The 1x OTD direct spreading system according to the second embodiment uses the quasi-orthogonal spreading codes of length 256, and the spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 11B.

In FIG. 7, when the first I and Q component symbols out of the symbols repeated by the symbol repeaters 160 and 162 of FIG. 1 are input to the adders 710 and 715, the adder 700 adds the Walsh code of length 128 and the leading 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG.

11B, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 128-chip input signals according to the leading 128-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 256. Thereafter, when the second I and Q component symbols out of the symbols repeated by the symbol repeaters 160 and 162 of FIG. 1 are input to the adders 710 and 715, the adder 700 adds the Walsh code of length 128 and the following 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 11B, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 128-chip input signals according to the following 128-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 256.

Referring to FIG. 11B, the first input symbol out of the symbols repeated by the symbol repeaters 160 and 162 of FIG. 1 is added to the Walsh code of length 128 and the leading 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the leading 128-chip portion of the phase component QOF_{rot} of the quasi-orthogonal code of length 256. Subsequently, in the same manner, the second input symbol is added to the Walsh code of length 128 and the following 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the following 128-chip portion of the phase component QOF_{rot} of the quasi-orthogonal code of length 256.

With regard to the second antenna, the spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 11C. When the first I and Q component symbols out of the symbols repeated by the symbol repeaters 164 and 166 of FIG. 1 are input to the

adders 710 and 715, the adder 700 adds the Walsh code of length 128 and the leading 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 11C, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 128-chip input signals according to the leading 128-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 256.

The second I and Q component symbols out of the symbols repeated by the symbol repeaters 164 and 166 of FIG. 1 are inverted symbols obtained by inverting the first I and Q component symbols. When the inverted symbols are input to the adders 710 and 715, the adder 700 adds the Walsh code of length 128 and the following 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 11C, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 128-chip input signals according to the following 128-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 256.

Referring to FIG. 11C, the first input symbol out of the symbols repeated by the symbol repeaters 164 and 166 of FIG. 1 is added to the Walsh code of length 128 and the leading 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the leading 128-chip portion of the phase component QOF_{rot} of the quasi-orthogonal code of length 256. Subsequently, in the same manner, the second input symbol obtained by inverting the first input symbol is added to the Walsh code of length 128 and the following 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the following 128-chip portion of the phase component QOF_{rot} of the quasi-orthogonal code

of length 256.

Further, a description will be made of spreading operation in the 3x non-OTD direct spreading system, with reference to FIGS. 7 and 11D. The 3x non-OTD direct spreading system according to the second embodiment uses the quasi-orthogonal spreading codes of length 256, and the spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 11D.

In FIG. 7, when the I and Q component symbols are input to the adders 710 and 715, the adder 700 adds the Walsh code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 11D, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 256. Referring to FIG. 11D, one input symbol is added to the Walsh code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the phase component QOF_{rot} of the quasi-orthogonal code of length 256.

Next, a description will be made of spreading operation in the 3x OTD direct spreading system with reference to FIGS. 7, 11E and 11F, wherein FIG. 11E shows a timing diagram of the first antenna and FIG. 11F shows a timing diagram of the second antenna.

The 3x OTD direct spreading system according to the second embodiment uses the spreading codes of length 256, and with regard to the first antenna, the spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 11E. When the I and Q

component symbols out of the symbols repeated by the symbol repeaters 160 and 162 of FIG. 1 are input to the adders 710 and 715, the adder 700 adds the Walsh code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 11E, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 256.

When the second I and Q component symbols out of the symbols repeated by the symbol repeaters 160 and 162 of FIG. 1 are input to the adders 710 and 715, the adder 700 adds the Walsh code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 11E, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 256.

Referring to FIG. 11E, the first input symbol out of the symbols repeated by the symbol repeaters 160 and 162 of FIG. 1 is added to the Walsh code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the phase component QOF_{rot} of the quasi-orthogonal code of length 256. Subsequently, in the same manner, the second input symbol is added to the Walsh code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the phase component QOF_{rot} of the quasi-orthogonal code of length 256.

With regard to the second antenna, the spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 11F. When the I and Q component symbols out of the symbols repeated by the symbol repeaters 164 and 166 of FIG. 1 are input to the adders 710 and 715, respectively, the adder 700 adds the Walsh code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 11F, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 256.

The second I and Q symbols out of the symbols repeated by the symbol repeaters 164 and 166 are the inverted symbols obtained by inverting the first symbols. When the inverted symbols are input to the adders 710 and 715, respectively, the adder 700 adds the Walsh code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 11F, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 256.

Referring to FIG. 11F, the first input symbols out of the symbols repeated by the symbol repeaters 164 and 166 of FIG. 1 are added to the Walsh code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the phase component QOF_{rot} of the quasi-orthogonal code of length 256. Subsequently, in the same manner, the second input symbols obtained by inverting the first symbols are added to the Walsh code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the phase

component QOF_{rot} of the quasi-orthogonal code of length 256.

Next, a description will be made of spreading operation in the 3x multicarrier system, with reference to FIGS. 7 and 11G. The 3x multicarrier system according to the second embodiment uses the spreading codes of length 256 for all the three carriers. The spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 11G.

When the I and Q component symbols are input to the adders 710 and 715, the adder 700 adds the Walsh code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 11G, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 256.

Referring to FIG. 11G, one input symbol is added to the Walsh code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the phase component QOF_{rot} of the quasi-orthogonal code of length 256.

C. Third Embodiment

In the third embodiment, the 1x direct spreading system uses the quasi-orthogonal codes of length 256, the 3x direct spreading system uses the quasi-orthogonal codes of length 512, and the 3x multicarrier system uses the quasi-orthogonal codes of length 256.

The 3x direct spreading system according to the third embodiment requires a mask function of length 512. In this context, the quasi-orthogonal sequences should have (1) a good full correlation property with the Walsh orthogonal codes, (2) a good full correlation property between the quasi-orthogonal codes, and (3) a good partial correlation property with the Walsh orthogonal codes, as disclosed in Korean patent application Nos. 99-888 and 99-1339, filed by the applicant. In addition, they should have a good partial correlation property between the quasi-orthogonal codes. The invention provides quasi-orthogonal codes that satisfy the above conditions.

Tables below show quasi-orthogonal sequence masks of length 512. More specifically, Tables 1 and 3 show the quasi-orthogonal codes expressed in quaternary values, satisfying the above conditions, wherein '0' indicates '1', '1' indicates 'j', '2' indicates '-1' and '3' indicates '-j'. Further, Tables 2 and 4 show the quasi-orthogonal codes expressed in polar coordinates comprised of the sign component QOF_{sign} and the phase component QOF_{rot}, wherein the phase component is equal to a specific Walsh code. Therefore, the respective signals are represented by W_i.

Table 1

$f(x)=1+x^1+x^2+x^4+x^5+x^7+x^9$ $g(x)=3+3x^1+x^2+x^4+3x^5+2x^6+3x^7+2x^8+x^9$
e1: 02113122221333021300021111202213003111202033130011202213130002 11 1322023311022231023331002231332011022231132202330013110220111322 3122021111200031021113000031330233022213130020330031330202111300 2011310022311102132220113320223122311102201131001102001331000233 2213112002111300330222133122021102111300221311201300203311200031 1102001313222011001333202011310031000233332022312011310000133320 3302003113000211003111200211312213000211330200312033130022133302 0013110202333100332000131322023320111322223133201322023333200013
e2: 0222333131112222020221131131100203331022222203111331302002202313 3 0222333131112220202211311311002011132000000213331131202200201311 1311220202001131133322200222111322021311113102000002311133312000 3133002020223313311100022000333122021311113102000002311133312000 0002311111130222002031331131020013332220200033313133002002001131 2220133333312000220213113313202213332220200033313133002002001131 3313020000201311111320002220311120221131313322022000111331112220

	3313020000201311111320002220311102003313131100200222333113330002
e3:	0130302323301223120101303001233010030332102103102110100321321021 3203031032210332031010210332100301121223231230231223233030230130 0332100303101021322103323203031012012312300101120130120123303001 1223011230232312011230012312120121321021211010031021031010030332 1003211032030310033210032132320301301201011212233023013030010112 2330122323121201122301121201013010210310322121100310320321101003 1201013012230112231212012330122303323221213210211003033232032132 0310102121103221102121323221033230010112302301300112122301301201
e4:	0121301023211210303223211232012112100103123201210121301001033032 1030210132300301212332300323103003011012032310301030210110122123 0103303223031232301023031210010330102303303223212321121023031232 3230030110302101032310302123323003231030030110121012212310302101 2101103003013230323021231030032310120301103003232101103021231012 3010012112102321232130320121123201031210012112323010012130320103 2123101203233212321221011012030132122101323021230301323003233212 1210232130100121012112322321303201211232010312103032010330100121

Table 2

$f(x)=1+x^1+x^2+x^4+x^5+x^7+x^9$ $g(x)=3+3x^1+x^2+x^4+3x^5+2x^6+3x^7+2x^8+x^9$	
Sign:	0100101111011101010001000010110100100010101101000010110101000100 0111011100011110011110001110111000011110011101110001000110000111 1011010000100010010001000010110111011101010010110010110101000100 1000100011100001011110001110111011100001100010000000100011000011 1101001001000100110111011011010001000100110100100100101100100010 0001000101111000000111101000100010000111111011101000100000011110 1101001001000100001000100100101101000100110100101011010011011101 0001000101111000111000010111011110000111111011100111011111100001
rot :	W214
Sign:	0111111010001110101100100100001011100111111010001101010011011011 0111111010001110101100100100001000011000000101110010101100100100 0100110101000010011111100111000111010100001001000001100011101000 1011001010111101100000011000111011010100001001000001100011101000 0001100000010111001010110010010001111110100011101011001001000010 1110011111101000110101001101101101111110100011101011001001000010 1101010000100100000110001110100010110010101111011000000110001110 1101010000100100000110001110100001001101010000100111111001110001
rot :	W172
Sign:	0010101111100111010000101000111000010111001001001000000110110010 1101010011100111010000100111000100010111111011011011111101011001 0111000101000010111001111101010001001101100000010010010011101000 0111000110111101000110001101010010110010100000010010010000010111 0001100011010100011100011011110100100100000101111011001010000001 1110011111010100011100010100001000100100111010000100110110000001 0100001001110001110101001110011101111110101100100001011111011011 0100001010001110001010111110011110000001101100100001011100100100

rot :	W375
Sign:	0010100011100100101111100111001001000001011100100010100000011011 0010100011100100101111100111001001000001011100100010100000011011 0001101111010111100011010100000110001101101111101110010011010111 1110010000101000011100101011111001110010010000010001101100101000 1000001001001110111010110010011100010100001001111000001010110001 1000001001001110111010110010011100010100001001111000001010110001 1011000101111101110110000001010011011000111010110100111001111101 0100111010000010001001111110101100100111000101001011000110000010
Rot :	W117

Table 3

$f(x)=1+x^2+x^3+x^5+x^6+x^8+x^9$ $g(x)=3+2x^1+3x^2+3x^3+2x^4+3x^5+x^6+3x^8+x^9$	
e1 :	0121103021231210210112322321323010120103123221013032030110300121 1210030110302303101223213010210121013010010332302303103021233032 3230232130100323121021233212230323033212030130320323301001031012 2101301001033230230310302123303212100301103023031012232130102101 1210030110302303101223213010210103231232232110120121321203011210 0121103021231210210112322321323032302321301003231210212332122303 0323123223211012012132120301121012100301103023031012232130102101 1012010312322101303203011030012123033212030130320323301001031012
e2 :	0222313311312220200013111131222031330222222011313133022200023313 0020111313330200002011133111202233312202202231111113002020223111 3111020022021113311102000020333102003111111322022022133311132202 3313222020003133113100022000313300021131131102220002113131332000 2000313333132220200031331131000213110222000211313133200000021131 2202111331110200002033313111020011132202020031111113220220221333 3111202222023331133302002202333102001333111300200200133333312202 3313000220001311331300020222313300023313131120002220113113112000
e3 :	0211223113223302132211200211001331001120203300130211001313221120 3122110202332213201122131300110202332213312211023122332002330031 0013203333021322330231000013021111203100223102110013021133023100 1102312200312011221320113320312200312011110231221102130000310233 3100330220332231021122311322330220332231310033023100112020330013 2011221313001102130033202011003131223320023300312011003113003320 3302310000130211223102111120310000130211330231003302132200132033 0031023311021300110231220031201133203122221320110031201111023122
e4 :	0130233030231223302330010130011203100332102110031021322103102110 2312011230231223302330012312233003100332320332213203100303102110 0130011212011223120130010130233003102110320310033203322103100332 2312233012011223120130012312011203102110102132211021100303100332 1021100321322110031021103203100330231223231201120130011212011223 3203322121322110031021101021322130231223013023302312233012011223 1021322103102110213221103203322130233001013001122312011212013001 3203100303102110213221101021100330233001231223300130233012013001

Table 4

$f(x)=1+x^2+x^3+x^5+x^6+x^8+x^9$ $g(x)=3+2x^1+3x^2+3x^3+2x^4+3x^5+x^6+3x^8+x^9$
Sign: 0010001010110100100001111110111000010001011110001011010000100010 0100010000101101000111101000100010001000000111101101001010111011 1110111010000111010010111101110111011101010010110111100000010001 1000100000011110110100101011101101000100001011010001111010001000 0100010000101101000111101000100001110111111000010010110101000100 0010001010110100100001111110111011101110100001110100101111011101 0111011111100001001011010100010001000100001011010001111010001000 0001000101111000101101000010001011011101010010110111100000010001
rot : W485
Sign: 0111101100101110100001000010111010110111111000101011011100011101 0010000101110100001000011000101111110110110111000000100101011000 1000010011010001100001000010111001001000000111011011011100011101 1101111010001011001000011000101100010010010001110001001010111000 1000101111011110100010110010000101000111000100101011100000010010 1101000110000100001011101000010000011101010010000001110110110111 1000101111011110011101001101111001000111000100100100011111101101 1101000110000100110100010111101100011101010010001110001001001000
rot : W172
Sign: 0100111001111101011100100100000110000010101100010100000101110010 1011000101111110110001101010000010111111011011000110111111001110010 0001101111010111111011000000101000010100011100100000101001101100 0 0001101100101000110110001110101100101000000110110001010000100111 1000110110111110010011100111111011011111101000110110000010101100 01 1000110101000000101001110100000101011111100111001010000001001001110 1101100000010100111001000010100000001010011011000110101110001101 1 0010011100010100000110110010100011101011110110000010100000011011
rot : W378
Sign: 0010111010110111101110000010000101000111001000010010111001001000 1101000110110111101110001101111001000111110111101101000101001000 0010000101000111010010000010111001001000110100011101111001000111 1101111001000111010010001101000101001000001011100010000101000111 0010000110111000010010001101000110110111110100010010000101000111 1101111010111000010010000010111010110111001011101101111001000111 0010111001001000101110001101111010111000001000011101000101001000 1101000101001000101110000010000110111000110111100010111001001000
rot : W283

First, a description will be made of spreading operation in the 1x non-OTD direct spreading system, with reference to FIGS. 7 and 12A. The 1x non-OTD direct spreading system according to the third embodiment uses the quasi-orthogonal spreading codes of length 256, and the spreading codes output from the rotator 720 of FIG. 7 are shown in

FIG. 12A.

In FIG. 7, when the I and Q component symbols are input to the adders 710 and 715, the adder 700 adds the Walsh code of length 128 and the leading 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 12A, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 128-chip input signals according to the leading 128-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 256. After this process, when the next I and Q component symbols are input to the adders 710 and 715, the adder 700 adds the Walsh code of length 128 and the following 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 12A, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 128-chip input signals according to the following 128-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 256.

Referring to FIG. 12A, one input symbol is added to the Walsh code of length 128 and the leading 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the leading 128-chip portion of the phase component QOF_{rot} of the quasi-orthogonal code of length 256. Subsequently, in the same manner, the next input symbol is added to the Walsh code of length 128 and the following 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the following 128-portion of the phase component QOF_{rot} of the quasi-orthogonal code of length 256.

Next, a description will be made of spreading operation in the 1x OTD direct spreading system, with reference to FIGS. 7, 12B and 12C, wherein FIG. 12B shows a timing diagram for the first antenna and FIG. 12C shows a timing diagram for the second antenna. The 1x OTD direct spreading system according to the third embodiment uses the quasi-orthogonal spreading codes of length 256, and with regard to the first antenna, the spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 12B.

In FIG. 7, when the first I and Q component symbols out of the symbols repeated by the symbol repeaters 160 and 162 of FIG. 1 are input to the adders 710 and 715, the adder 700 adds the Walsh code of length 128 and the leading 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 12B, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 128-chip input signals according to the leading 128-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 256. Thereafter, when the second I and Q component symbols out of the symbols repeated by the symbol repeaters 160 and 162 of FIG. 1 are input to the adders 710 and 715, respectively, the adder 700 adds the Walsh code of length 128 and the following 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 12B, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 128-chip input signals according to the following 128-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 256.

Referring to FIG. 12B, the first input symbol out of the symbols repeated by the symbol repeaters 160 and 162 of FIG. 1 is added to the Walsh code of length 128 and the

leading 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the leading 128-chip portion of the phase component QOF_{rot} of the quasi-orthogonal code of length 256. Subsequently, in the same manner, the second input symbol is added to the Walsh code of length 128 and the following 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the following 128-chip portion of the phase component QOF_{rot} of the quasi-orthogonal code of length 256.

With regard to the second antenna, the spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 12C. When the first I and Q component symbols out of the symbols repeated by the symbol repeaters 164 and 166 of FIG. 1 are input to the adders 710 and 715, respectively, the adder 700 adds the Walsh code of length 128 and the leading 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 12C, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 128-chip input signals according to the leading 128-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 256.

The second I and Q component symbols out of the symbols repeated by the symbol repeaters 164 and 166 of FIG. 1 are inverted symbols obtained by inverting the first I and Q component symbols. When the inverted symbols are input to the adders 710 and 715, the adder 700 adds the Walsh code of length 128 and the following 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 12C, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then

rotates the 128-chip input signals according to the following 128-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 256.

Referring to FIG. 12C, the first input symbol out of the symbols repeated by the symbol repeaters 164 and 166 of FIG. 1 is added to the Walsh code of length 128 and the leading 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the leading 128-chip portion of the phase component QOF_{rot} of the quasi-orthogonal code of length 256. Subsequently, in the same manner, the second input symbol obtained by inverting the first input symbol is added to the Walsh code of length 128 and the following 128-chip portion of the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the following 128-chip portion of the phase component QOF_{rot} of the quasi-orthogonal code of length 256.

Next, a description will be made of spreading operation in the 3x non-OTD direct spreading system, with reference to FIGS. 7 and 12D. The 3x non-OTD direct spreading system according to the third embodiment uses the quasi-orthogonal spreading codes of length 512, and the spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 12D.

In FIG. 7, when the I and Q component symbols are input to the adders 710 and 715, respectively, the adder 700 adds the Walsh code of length 256 and the leading 256-chip portion of the sign component QOF_{sign} of the quasi-orthogonal sequence of length 512, as shown in FIG. 12D, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the leading 256-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 512.

After this process, when the next I and Q component symbols are input to the adders 710 and 715, the adder 700 adds the Walsh code of length 256 and the following 256-chip portion of the sign component QOF_{sign} of the quasi-orthogonal sequence of length 512, as shown in FIG. 12D, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the following 256-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 512.

Referring to FIG. 12D, one input symbol is added to the Walsh code of length 256 and the leading 256-chip portion of the sign component QOF_{sign} of the quasi-orthogonal code of length 512, and then rotated according to the leading 256-chip portion of the phase component QOF_{rot} of the quasi-orthogonal code of length 512. Subsequently, the next input symbol is added to the Walsh code of length 256 and the following 256-chip portion of the sign component QOF_{sign} of the quasi-orthogonal code of length 512, and then rotated according to the following 256-portion of the phase component QOF_{rot} of the quasi-orthogonal code of length 512.

Further, a description will be made of spreading operation in the 3x OTD direct spreading system, with reference to FIGS. 7, 12E and 12F, wherein FIG. 12E shows the timing diagram for the first antenna and FIG. 12F shows the timing diagram for the second antenna. The 3x OTD direct spreading system according to the third embodiment uses the quasi-orthogonal spreading codes of length 512.

With regard to the first antenna, the spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 12E. In FIG. 7, when the I and Q component symbols are input to the adders 710 and 715, respectively, the adder 700 adds the Walsh code of length 256 and the leading 256-chip portion of the sign component QOF_{sign} of the quasi-

orthogonal sequence of length 512, as shown in FIG. 12E, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the leading 256-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 512. When the second I and Q component symbols out of the symbols repeated by the symbol repeaters 160 and 162 of FIG. 1 are input to the adders 710 and 715, respectively, the adder 700 adds the Walsh code of length 256 and the following 256-chip portion of the sign component QOF_{sign} of the quasi-orthogonal sequence of length 512, as shown in FIG. 12E, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the following 256-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 512.

Referring to FIG. 12E, the first input symbol out of the symbols repeated by the symbol repeaters 160 and 162 of FIG. 1 is added to the Walsh code of length 256 and the leading 256-chip portion of the sign component QOF_{sign} of the quasi-orthogonal code of length 512, and then rotated according to the leading 256-chip portion of the phase component QOF_{rot} of the quasi-orthogonal code of length 512. Subsequently, in the same manner, the second input symbol is added to the Walsh code of length 256 and the following 256-chip portion of the sign component QOF_{sign} of the quasi-orthogonal code of length 512, and then rotated according to the following 256-chip portion of the phase component QOF_{rot} of the quasi-orthogonal code of length 512.

With regard to the second antenna, the spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 12F. When the I and Q component symbols out of the

symbols repeated by the symbol repeaters 164 and 166 of FIG. 1 are input to the adders 710 and 715, respectively, the adder 700 adds the Walsh code of length 256 and the leading 256-chip portion of the sign component QOF_{sign} of the quasi-orthogonal sequence of length 512, as shown in FIG. 12F, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the leading 256-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 512.

The second I and Q symbols out of the symbols repeated by the symbol repeaters 164 and 166 are the inverted symbols obtained by inverting the first symbols. When the inverted symbols are input to the adders 710 and 715, respectively, the adder 700 adds the Walsh code of length 256 and the following 256-chip portion of the sign component QOF_{sign} of the quasi-orthogonal sequence of length 512, as shown in FIG. 12F, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the following 256-chip portion of the input phase component QOF_{rot} of the quasi-orthogonal code of length 512.

Referring to FIG. 12F, the first input symbols out of the symbols repeated by the symbol repeaters 164 and 166 of FIG. 1 are added to the Walsh code of length 256 and the leading 256-chip portion of the sign component QOF_{sign} of the quasi-orthogonal code of length 512, and then rotated according to the leading 256-chip portion of the phase component QOF_{rot} of the quasi-orthogonal code of length 512. Subsequently, in the same manner, the second input symbols obtained by inverting the first symbols are added to the Walsh code of length 256 and the following 256-chip portion of the sign component

QOF_{sign} of the quasi-orthogonal code of length 512, and then rotated according to the following 256-chip portion of the phase component QOF_{rot} of the quasi-orthogonal code of length 512.

Next, a description will be made of spreading operation in the 3x multicarrier system, with reference to FIGS. 7 and 12G. The 3x multicarrier system according to the third embodiment uses the spreading codes of length 256 for all the three carriers. The spreading codes output from the rotator 720 of FIG. 7 are shown in FIG. 12G.

When the I and Q component symbols are input to the adders 710 and 715, respectively, the adder 700 adds the Walsh code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal sequence of length 256, as shown in FIG. 12G, and provides the added signals to the adders 710 and 715. The adders 710 and 715 then add the I and Q component symbols, respectively, to the signals output from the adder 700, and provide the added signals to the rotator 720. The rotator 720 then rotates the 256-chip input signals according to the input phase component QOF_{rot} of the quasi-orthogonal code of length 256.

Referring to FIG. 12G, one input symbol is added to the Walsh code of length 256 and the sign component QOF_{sign} of the quasi-orthogonal code of length 256, and then rotated according to the phase component QOF_{rot} of the quasi-orthogonal code of length 256.

As described above, the novel device and method can minimize interference between the spreading codes in the OTD direct spreading system and multicarrier system. Particularly, when overlay occurs at a certain carrier in the multicarrier system, it is possible to minimize the interference between 1x user and the 3x user.

While the invention has been shown and described with reference to a certain preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

WHAT IS CLAIMED IS:

1. A channel spreading method in a CDMA (Code Division Multiple Access) communication system which spreads a pair of symbols obtained by repeating a first symbol with a quasi-orthogonal code having a given length to transmit the spread symbols through a first antenna and spreads a second symbol and an inverted symbol of said second symbol obtained by repeating said second symbol with said quasi-orthogonal code to transmit the spread symbols through a second antenna at the same time, the method comprising the steps of:

spreading one of said pair of symbols obtained by repeating said first symbol with a portion of said quasi-orthogonal code and spreading another symbol of said pair of symbols with a remaining portion of said quasi-orthogonal code; and

spreading the second symbol with a portion of said quasi-orthogonal code and spreading said inverted symbol of said second symbol with the remaining portion of said quasi-orthogonal code.

2. The channel spreading method as claimed in claim 1, wherein the quasi-orthogonal code spreading step comprises the step of mixing one symbol with a chip signal of a first half period of the quasi-orthogonal code and mixing another symbol with a chip signal of a second half period of the quasi-orthogonal code, so as to spread two symbols for duration of one quasi-orthogonal code.

3. The channel spreading method as claimed in claim 2, further comprising the steps of:

generating a mask index and a Walsh code index corresponding to an input index for generating the quasi-orthogonal code;

generating a mask for the quasi-orthogonal code corresponding to the mask index, and generating a Walsh code corresponding to the Walsh code index; and

outputting, as the quasi-orthogonal code, a quasi-orthogonal code generated by mixing a mask for the generated second quasi-orthogonal code with the Walsh code.

4. A channel spreading device in a CDMA communication system having first and second antennas to perform an orthogonal transmit diversity function, comprising:

a first transmitter having a first spreader for spreading a pair of symbols obtained by repeating a first symbol with a quasi-orthogonal code having a given length to transmit the spread symbols through a first antenna, spreading one of said pair of symbols with a portion of said quasi-orthogonal code and spreading another symbol of said pair of symbols with a remaining portion of said quasi-orthogonal code; and

a second transmitter having a second spreader for spreading a second symbol and an inverted symbol of said second symbol obtained by repeating said second symbol with said quasi-orthogonal code to transmit the spread symbols through a second antenna, spreading said second symbol with a portion of said quasi-orthogonal code and spreading said inverted symbol of said second symbol with the remaining portion of said quasi-orthogonal code.

5. The channel spreading device as claimed in claim 4, wherein each of the first and second spreaders mixes one symbol with a chip signal of a first half period of the quasi-orthogonal code and mixes another symbol with a chip signal of a second half period of the quasi-orthogonal code, so as to spread two symbols for duration of one quasi-orthogonal code.

6. The channel spreading device as claimed in claim 5, further comprising:

a controller for generating a mask index and a Walsh code index corresponding to an input index for generating the second quasi-orthogonal code;

a mask generator for generating a mask for the second quasi-orthogonal code

corresponding to the mask index;

a Walsh code generator for generating a Walsh code corresponding to the Walsh code index; and

a spreading code generator for outputting, as the quasi-orthogonal code, the second quasi-orthogonal code generated by mixing a mask for the generated second quasi-orthogonal code with the Walsh code.

7. A channel spreading method in a CDMA (Code Division Multiple Access) communication system comprising the steps of:

duplicating a first input symbol to create a first pair of symbols;

matching a second input symbol with its complement to create a second pair of symbols;

spreading the first pair of symbols by a first quasi-orthogonal code in order to transmit the spread first pair of symbols through a first antenna; and

spreading the second pair of symbols by a second quasi-orthogonal code in order to transmit the spread second pair of symbols through a second antenna.

8. The channel spreading method in claim 7 wherein the first and second quasi-orthogonal codes are the same.

9. The channel spreading method in claim 7 wherein the first and second quasi-orthogonal codes are different.

10. The channel spreading method in claim 7 wherein one of the first pair of symbols is spread by a portion of the first quasi-orthogonal code and other of the first pair of symbols is spread by the remaining portion of the first quasi-orthogonal code.

11. The channel spreading method in claim 7 wherein one of the second pair

of symbols is spread by a portion of the second quasi-orthogonal code and other of the second pair of symbols is spread by the remaining portion of the second quasi-orthogonal code.

ABSTRACT

A channel spreading method in a CDMA communication system which spreads a pair of symbols obtained by repeating one symbol with a quasi-orthogonal code having a given length to transmit the spread symbols through a first antenna and spreads said symbol and an inverted symbol of said symbol with said quasi-orthogonal code to transmit the spread symbols through a second antenna. The method comprises spreading one of said pair of symbols with a portion of said quasi-orthogonal code and spreading another symbol of said pair of symbols with a remaining portion of said quasi-orthogonal code; and spreading said symbol with a portion of said quasi-orthogonal code and spreading said inverted symbol with the remaining portion of said quasi-orthogonal code.

FIG. 1

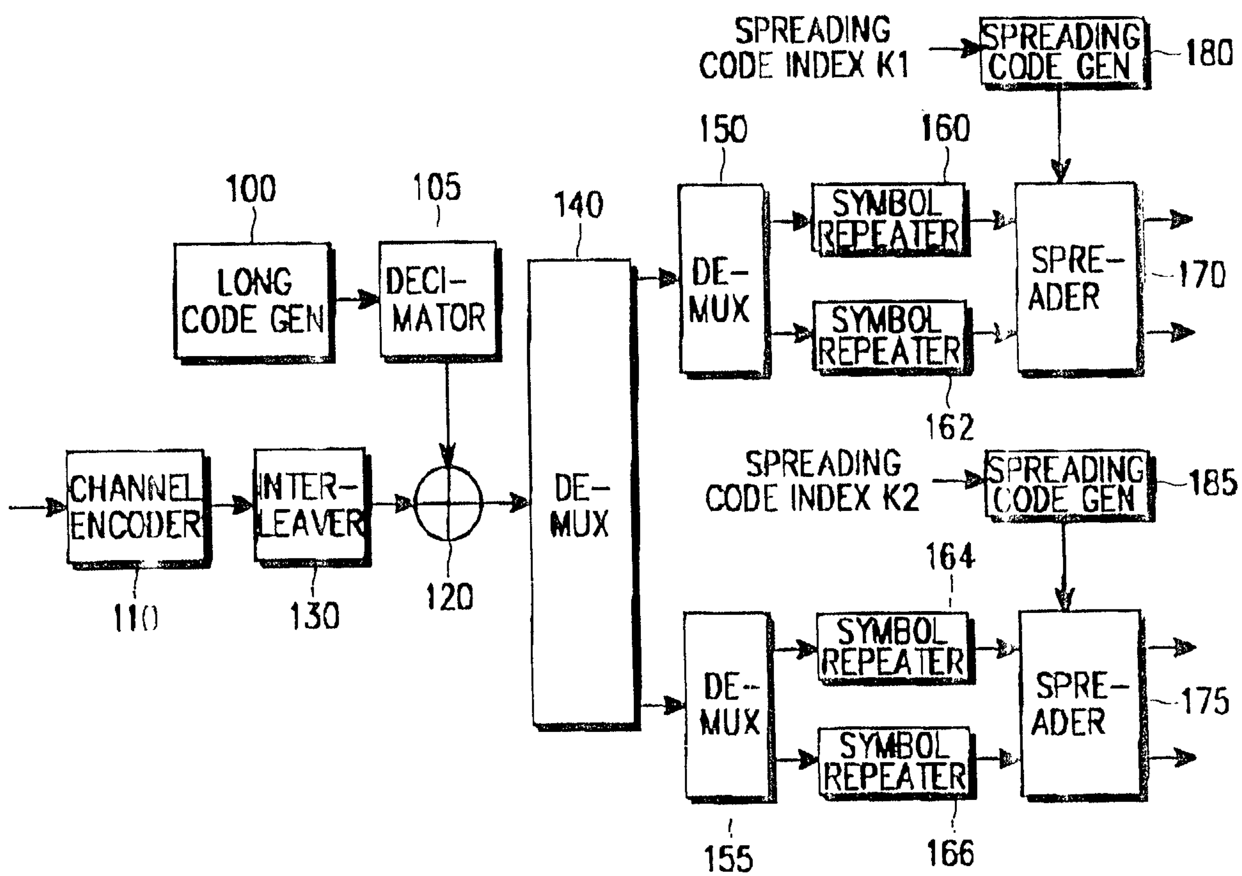

SPREADING
CODE INDEX K1
SPREADING
CODE GEN
180
150
160
100
105
140
LONG
CODE GEN
DECI-
MATOR
DE-
MUX
SYMBOL
REPEATER
SPRE-
ADER
170
SYMBOL
REPEATER
162
CHANNEL
ENCODER
INTER-
LEAVER
DE-
MUX
SPREADING
CODE INDEX K2
SPREADING
CODE GEN
185
110
130
120
164
DE-
MUX
SYMBOL
REPEATER
SPRE-
ADER
175
SYMBOL
REPEATER
155
166

FIG. 2

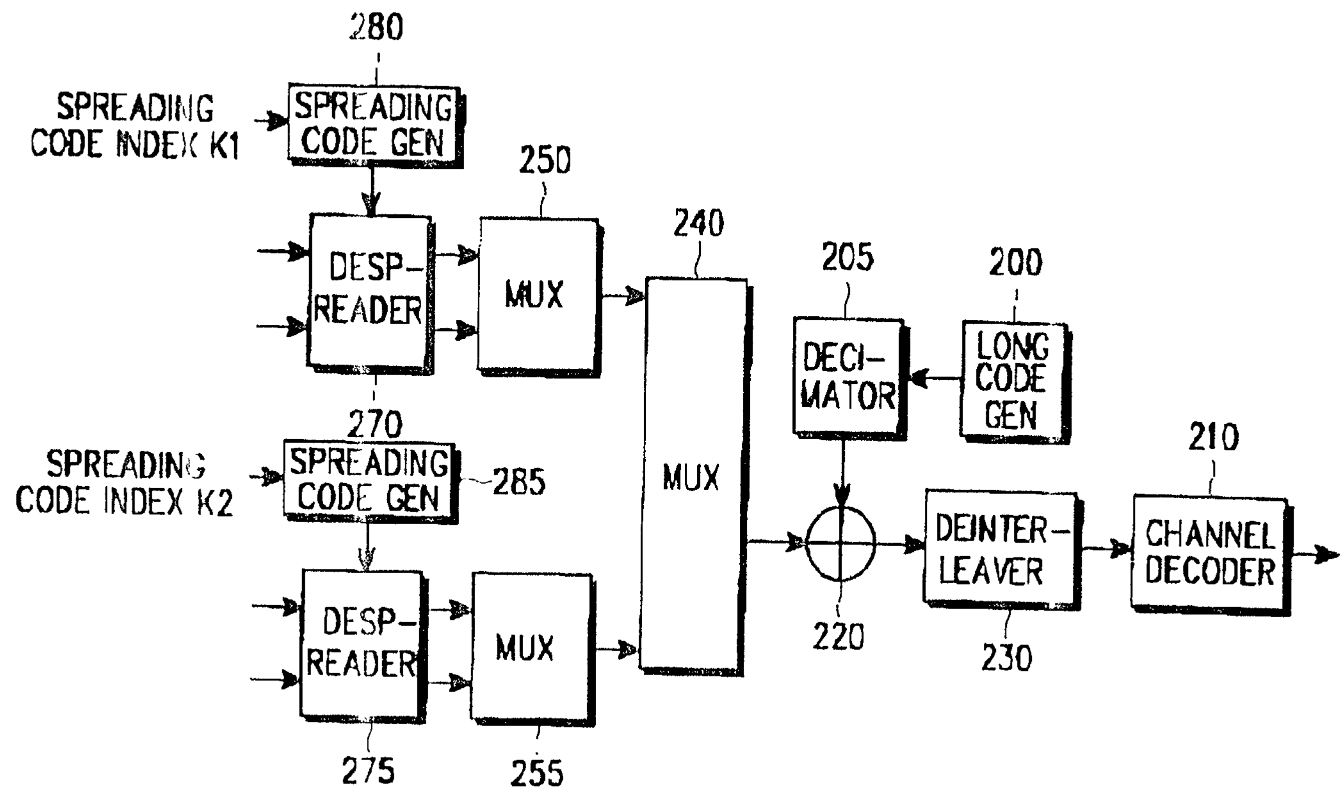
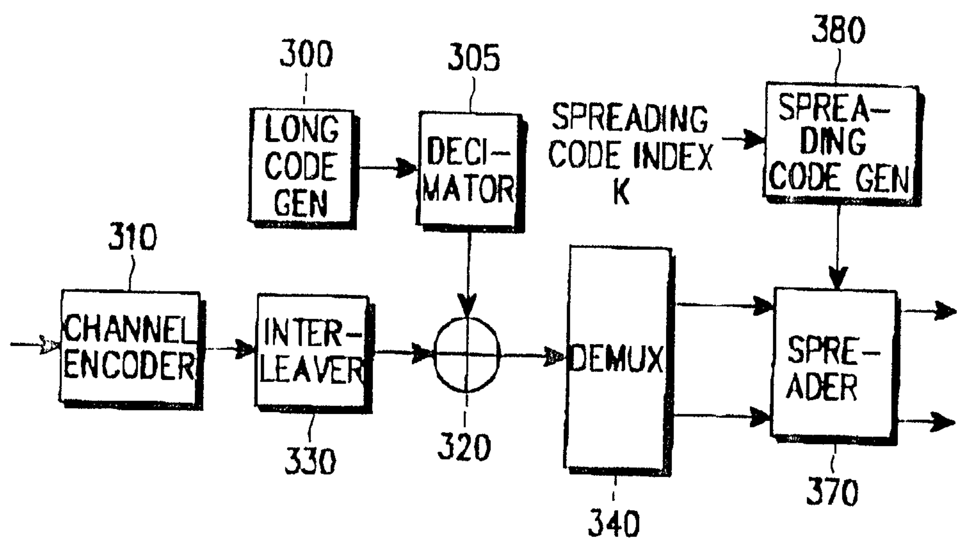

280
SPREADING CODE INDEX K1
SPREADING CODE GEN
250
DESP-READER
MUX
240
205
200
DECI-MATOR
LONG CODE GEN
270
SPREADING CODE INDEX K2
SPREADING CODE GEN
285
MUX
210
DEINTER-LEAVER
CHANNEL DECODER
DESP-READER
MUX
220
230
275
255

FIG. 3



300
LONG CODE GEN
305
DECI-MATOR
SPREADING CODE INDEX K
380
SPREA-DING CODE GEN
310
CHANNEL ENCODER
INTER-LEAVER
330
320
DEMUX
340
SPRE-ADER
370

FIG. 4

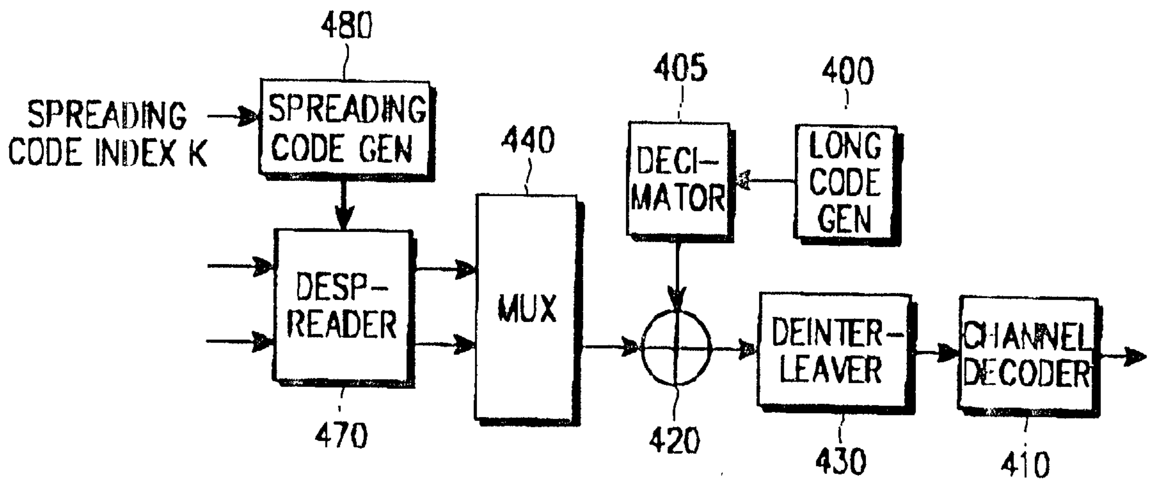

480
SPREADING CODE INDEX K
SPREADING CODE GEN
440
405
400
DECI-MATOR
LONG CODE GEN
DESP-READER
MUX
DEINTER-LEAVER
CHANNEL DECODER
470
420
430
410

FIG. 5

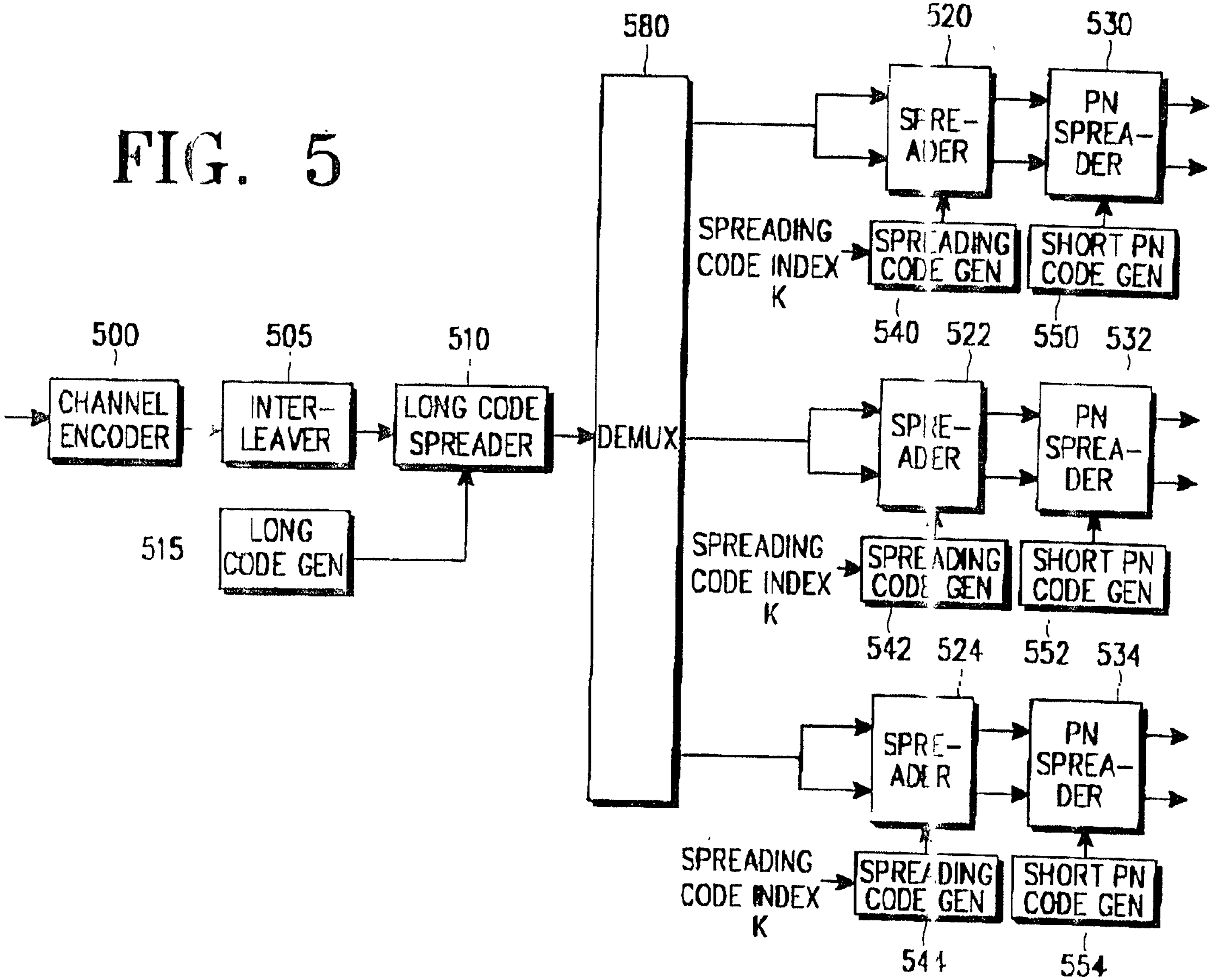
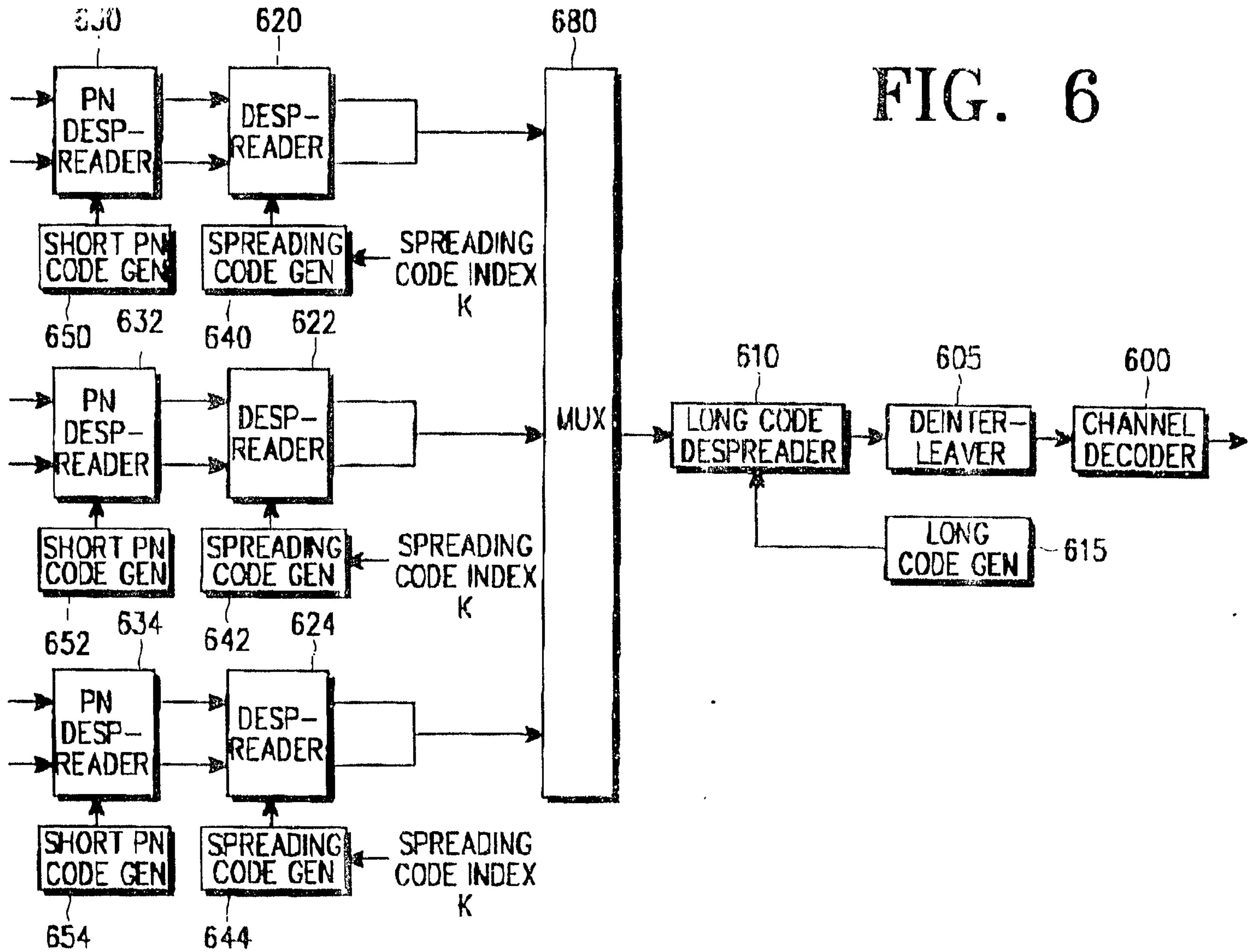
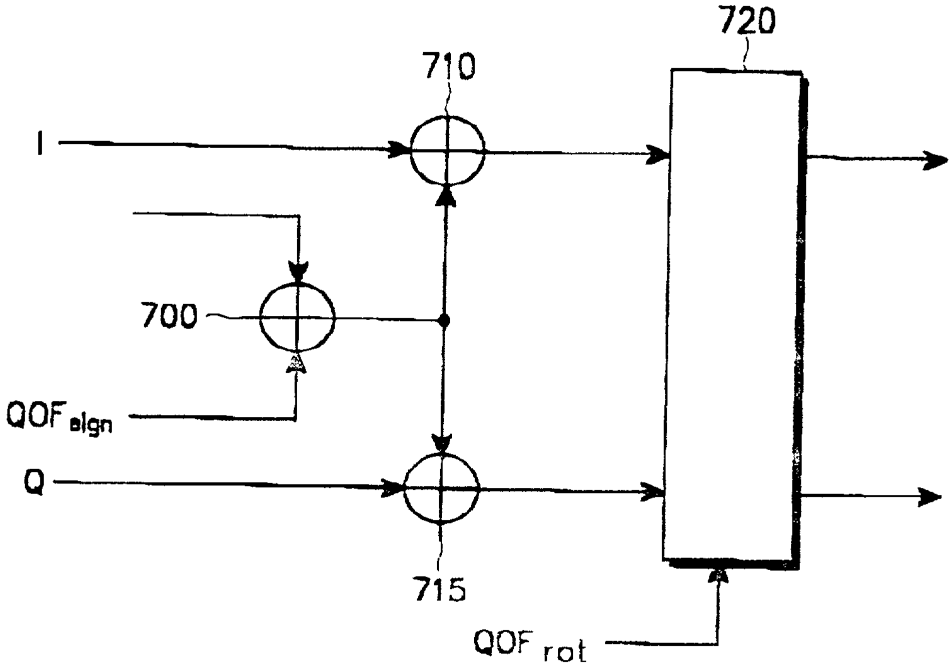

500
CHANNEL ENCODER
505
INTER-LEAVER
510
LONG CODE SPREADER
515
LONG CODE GEN
580
DEMUX
520
SPRE-ADER
530
PN SPREA-DER
SPREADING CODE INDEX K
SPREADING CODE GEN
540
SHORT PN CODE GEN
550
522
SPRE-ADER
532
PN SPREA-DER
SPREADING CODE INDEX K
SPREADING CODE GEN
542
SHORT PN CODE GEN
552
524
SPRE-ADER
534
PN SPREA-DER
SPREADING CODE INDEX K
SPREADING CODE GEN
544
SHORT PN CODE GEN
554

FIG. 6

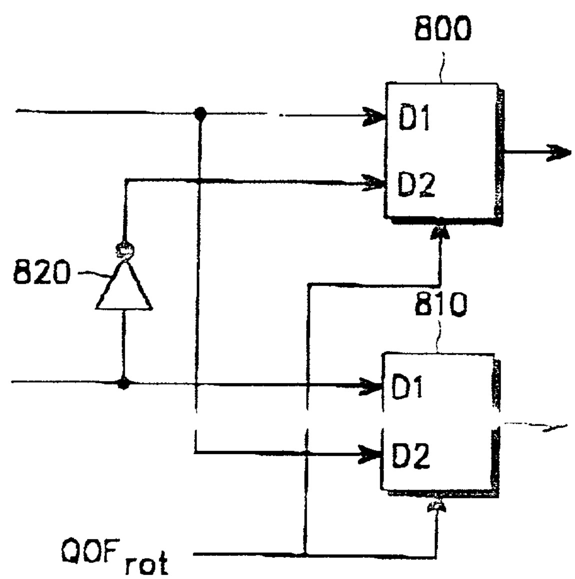


630
620
680
PN DESP-READER
DESP-READER
SHORT PN CODE GEN
SPREADING CODE GEN
SPREADING CODE INDEX K
650
632
640
622
PN DESP-READER
DESP-READER
SHORT PN CODE GEN
SPREADING CODE GEN
SPREADING CODE INDEX K
652
634
642
624
PN DESP-READER
DESP-READER
SHORT PN CODE GEN
SPREADING CODE GEN
SPREADING CODE INDEX K
654
644
MUX
610
605
600
LONG CODE DESPREADER
DEINTER-LEAVER
CHANNEL DECODER
LONG CODE GEN
615



720
710
I
700
QOF_{sign}
Q
715
QOF_{rot}

FIG. 7



800
D1
D2
820
810
D1
D2
QOF_{rot}

FIG. 8

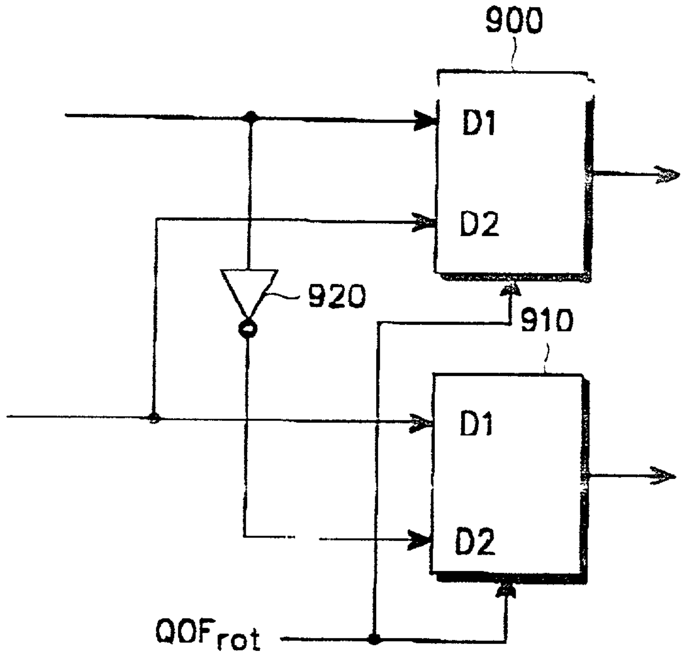


FIG. 9

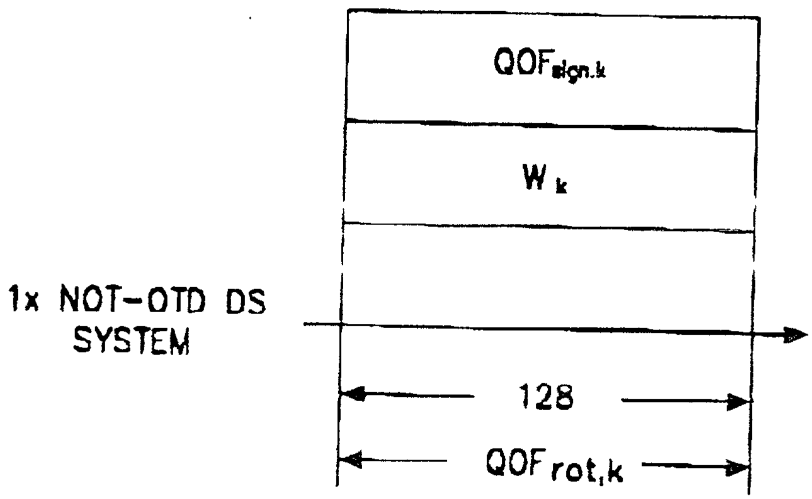


FIG. 10A

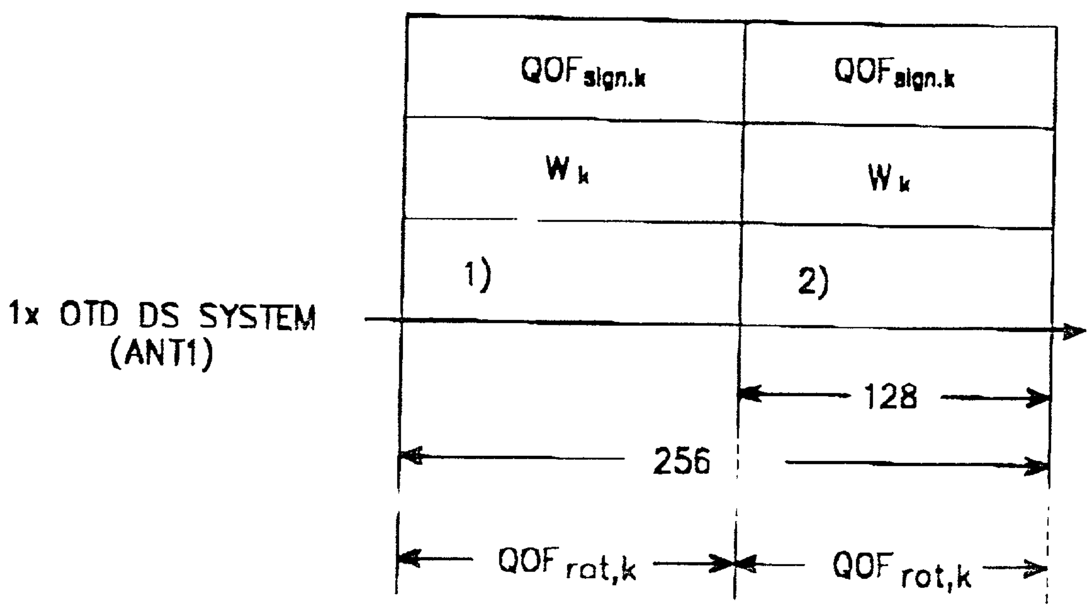


FIG. 10B

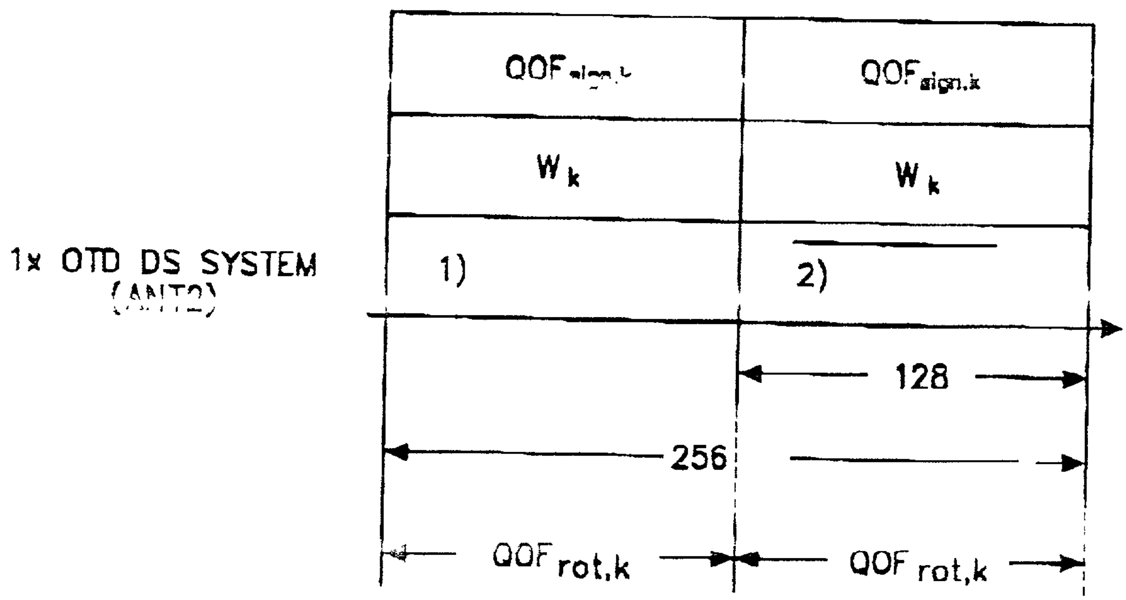


FIG. 10C

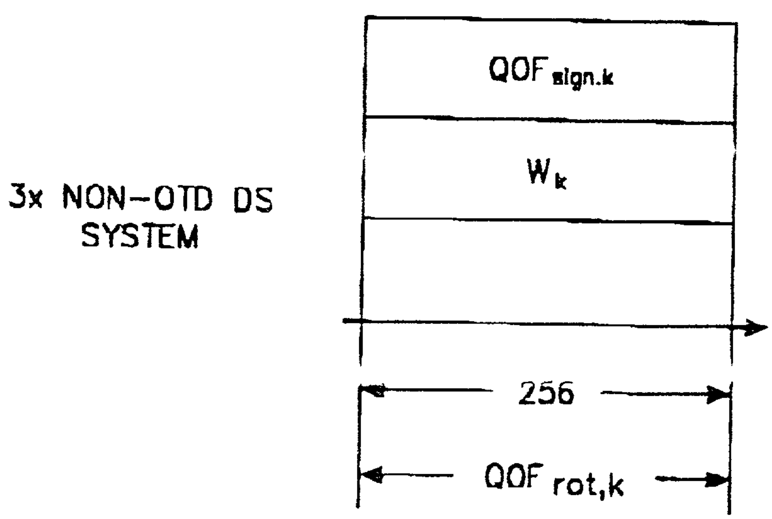


FIG. 10D

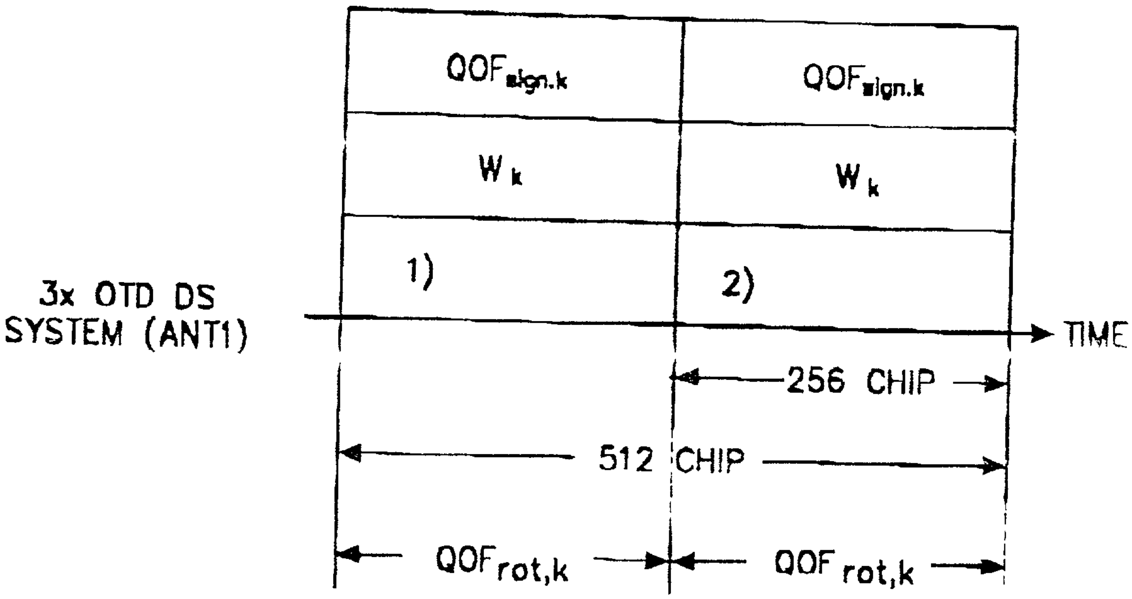


FIG. 10E

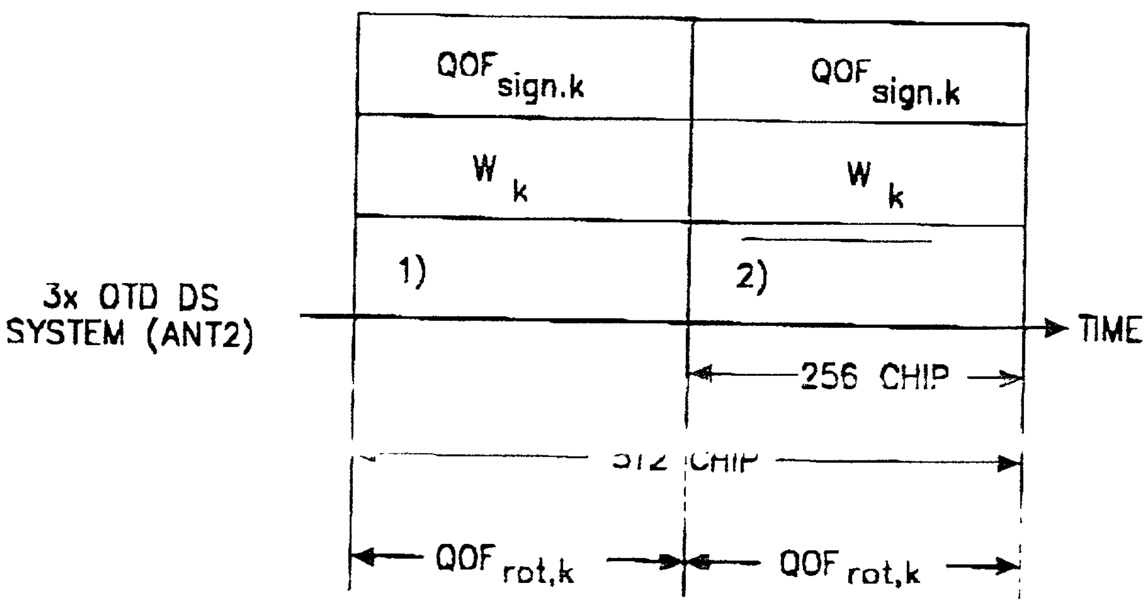


FIG. 10F

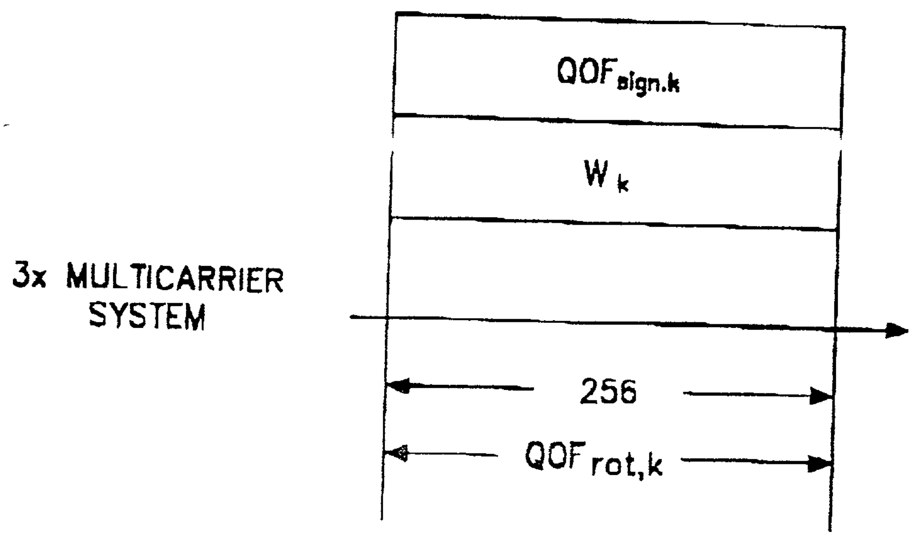


FIG. 10G

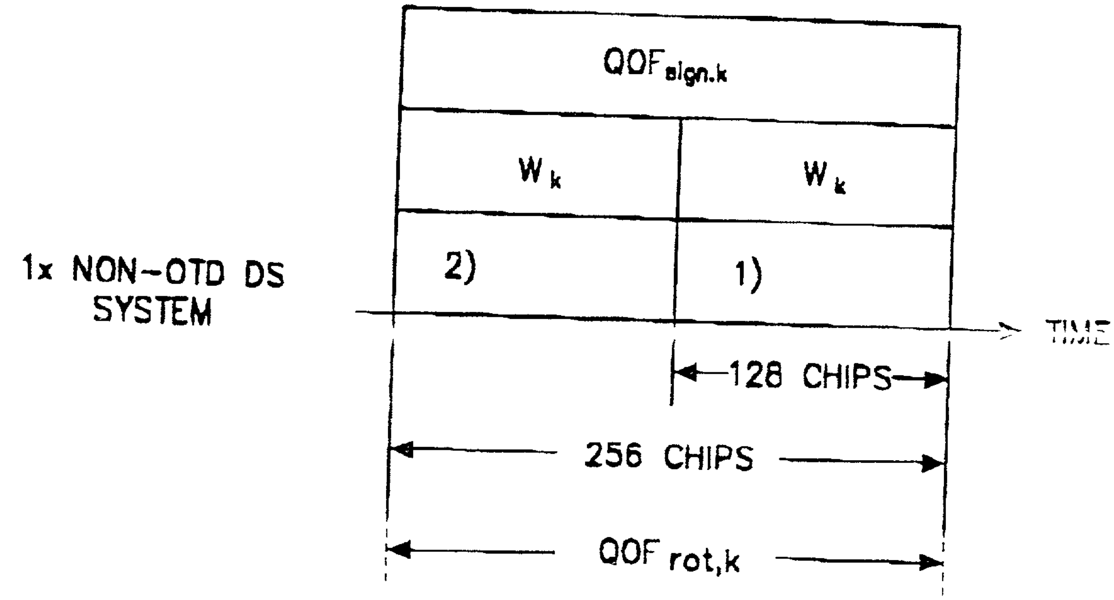


FIG. 11A

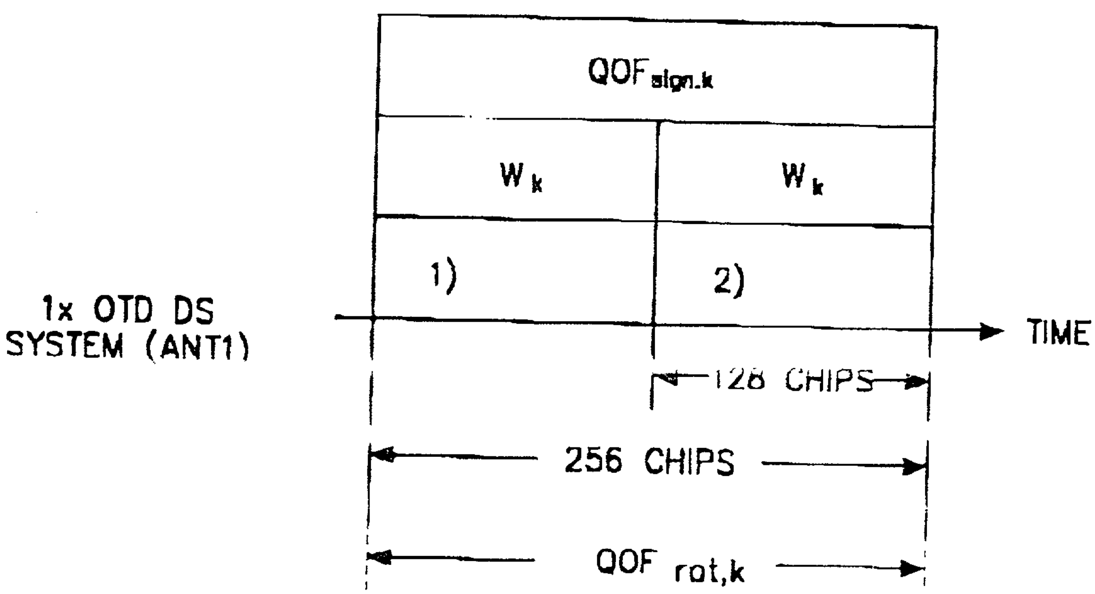


FIG. 11B

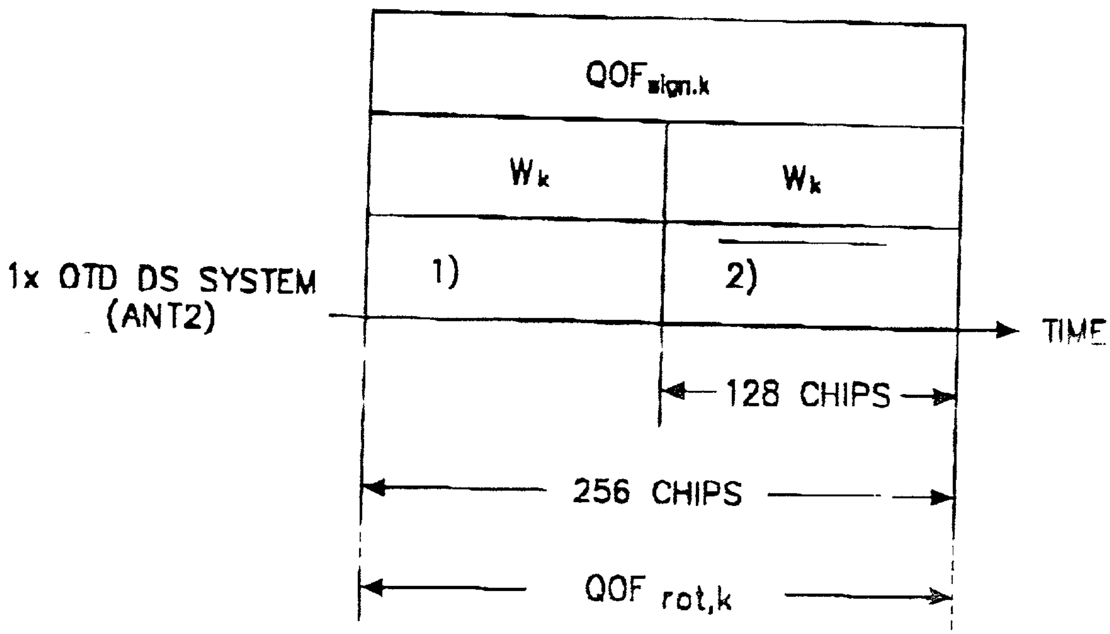


FIG. 11C

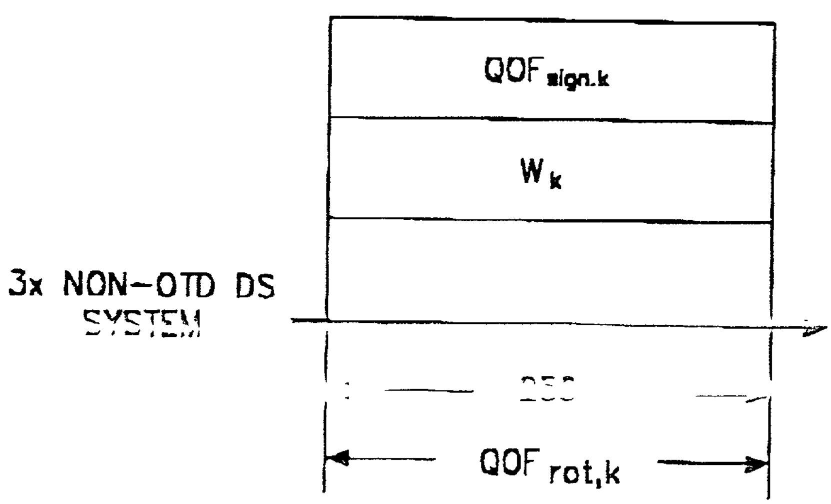


FIG. 11D

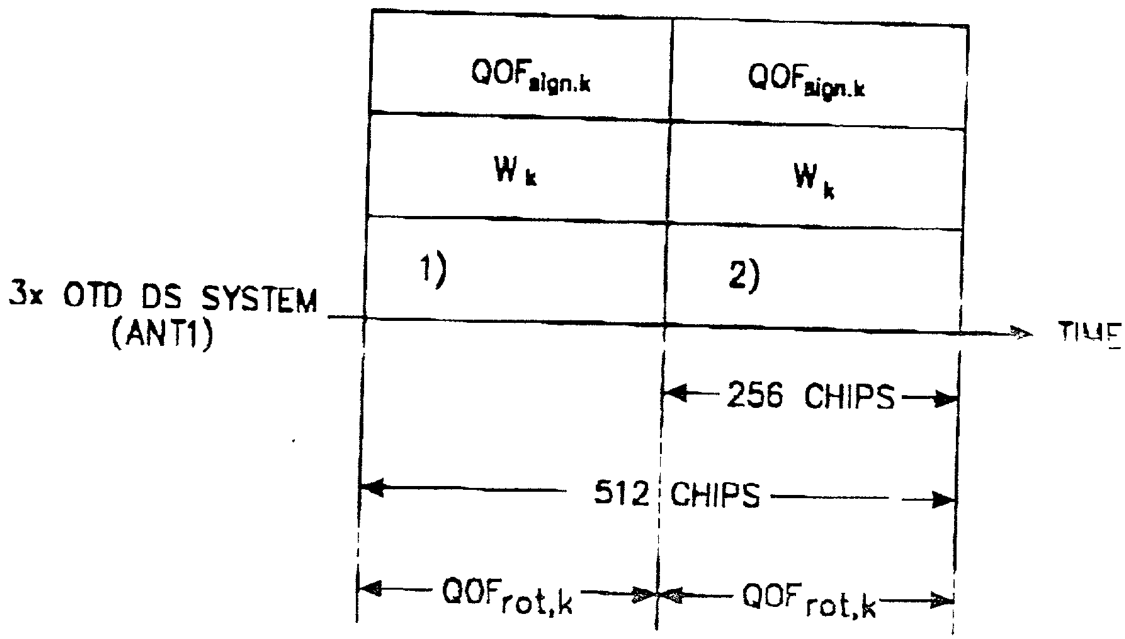


FIG. 11E

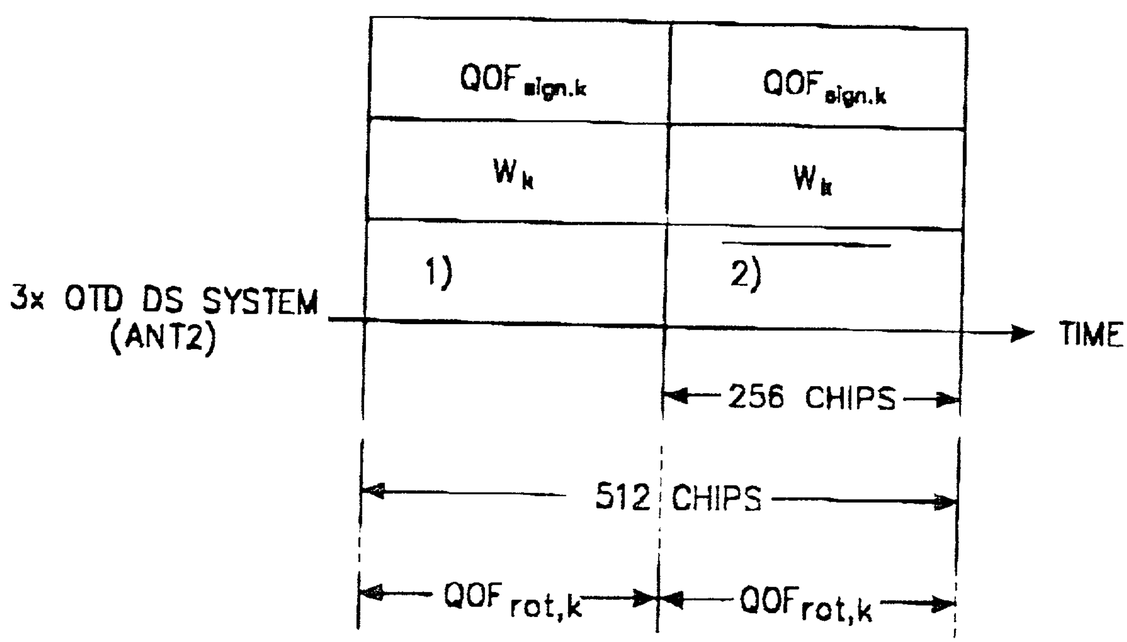


FIG. 11F

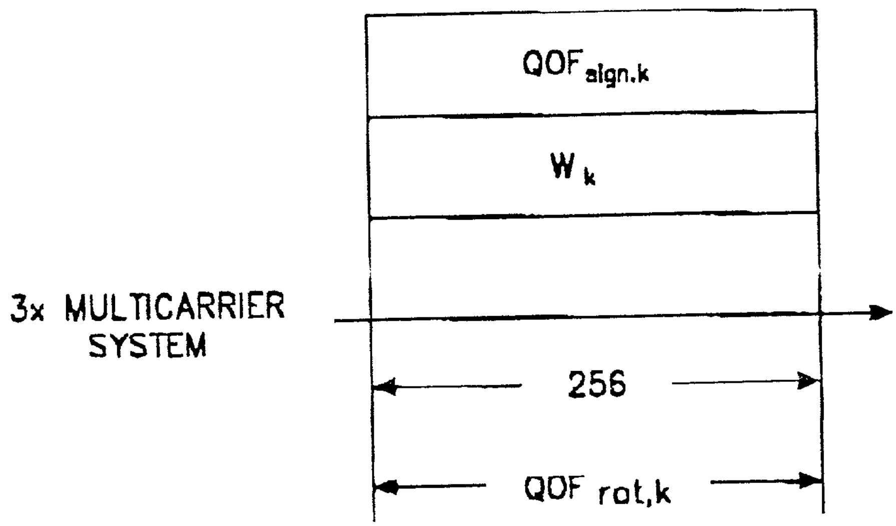


FIG. 11G

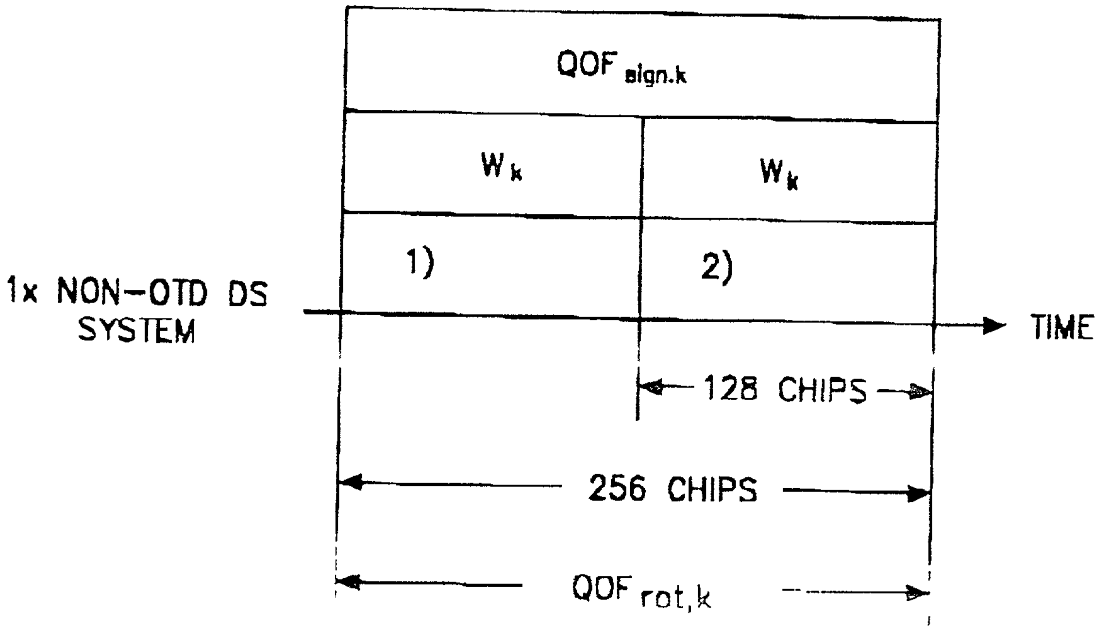


FIG. 12A

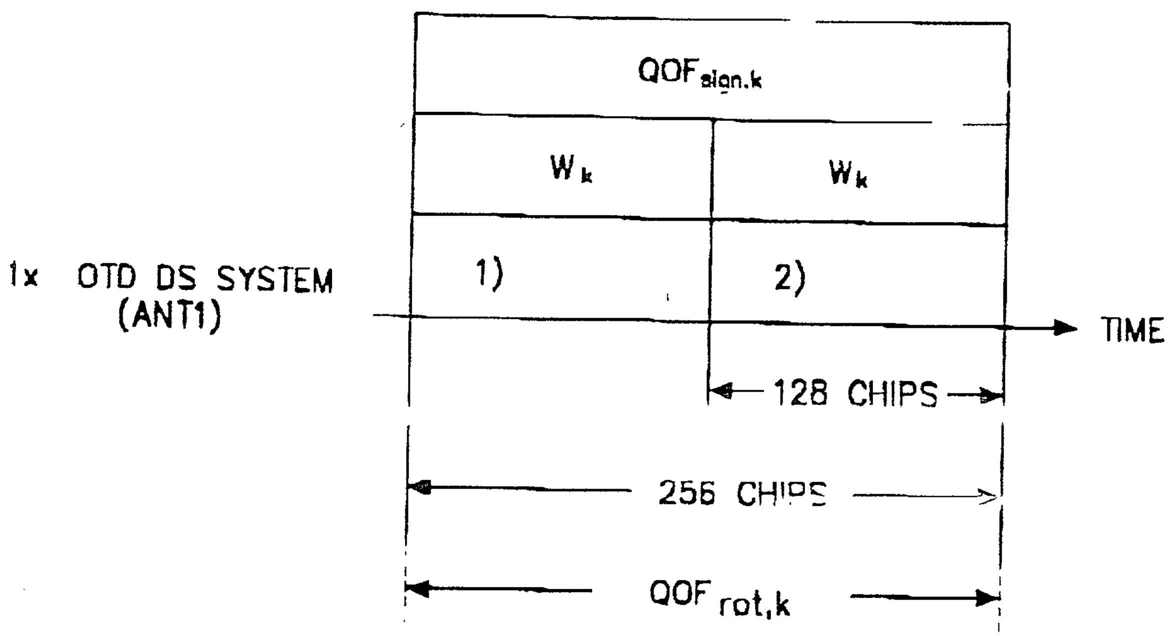


FIG. 12B

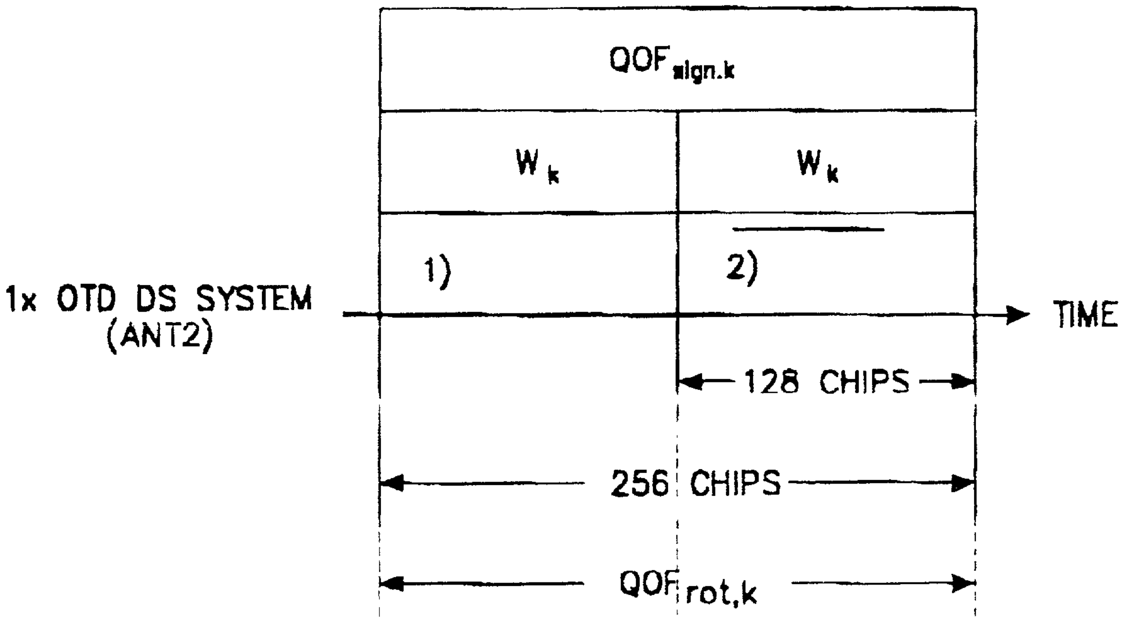


FIG. 12C

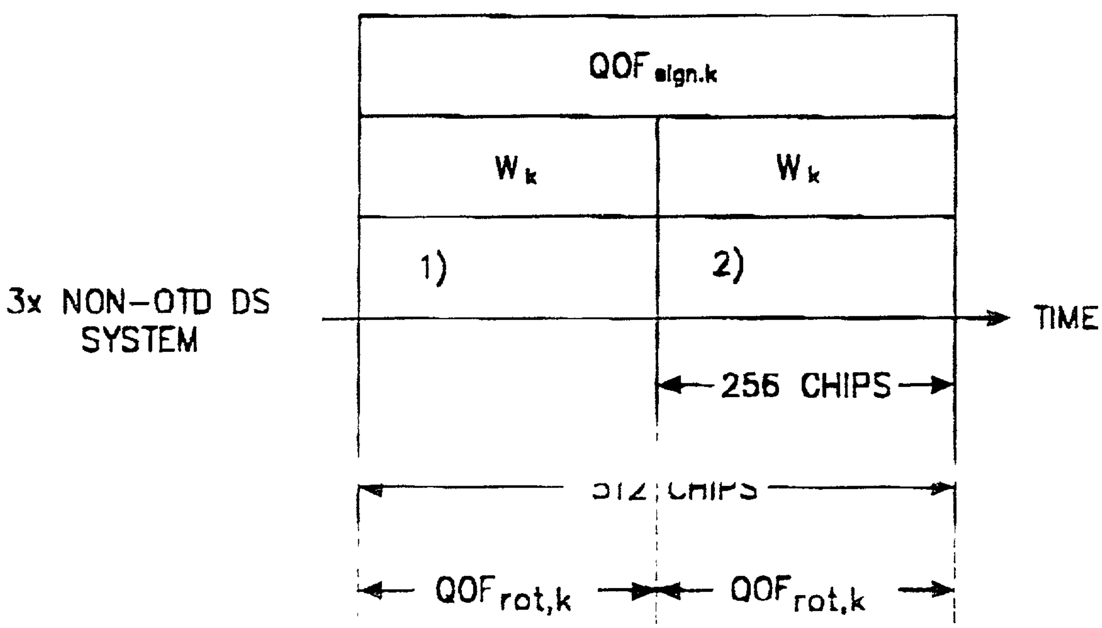


FIG. 12D

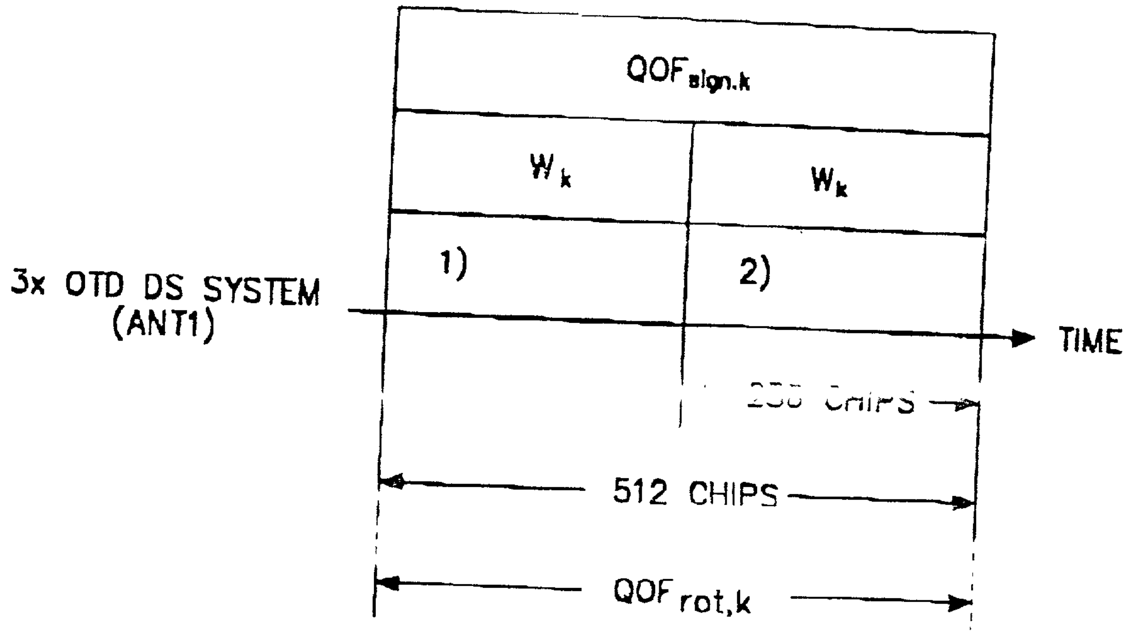


FIG. 12E

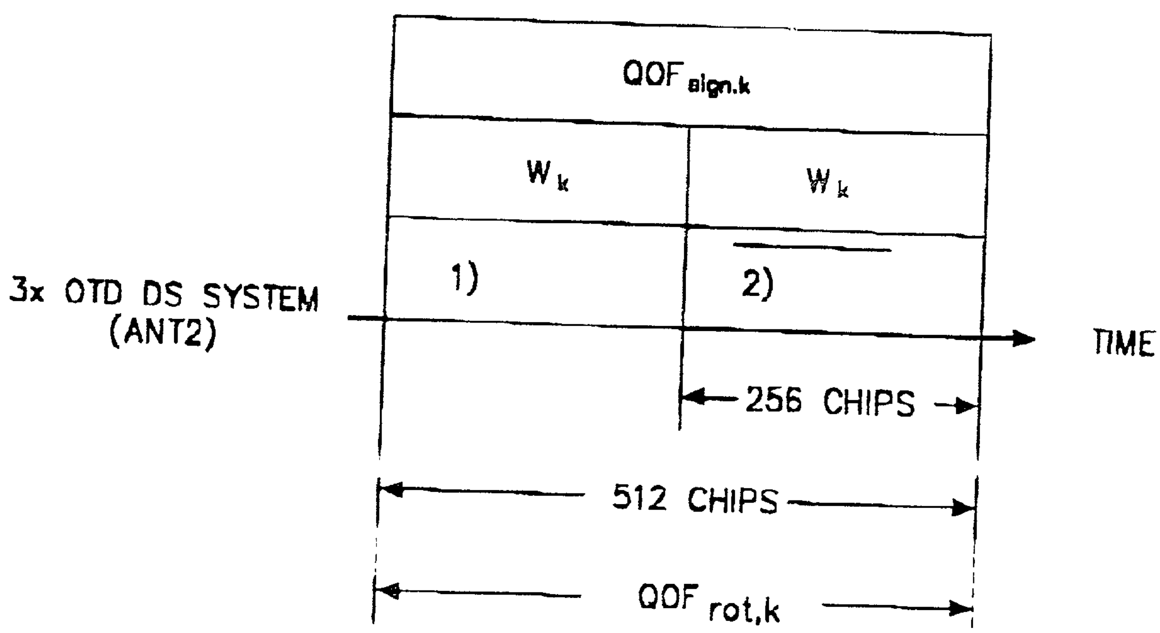


FIG. 12F

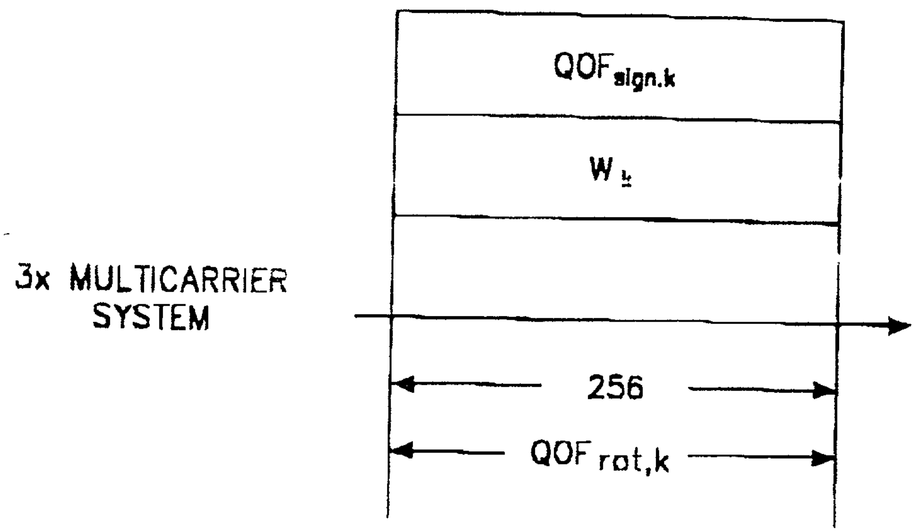


FIG. 12G

PTO/SB/01 (6/96) **DECLARATION** Docket No. 678-452 (P9148)

AS A BELOW NAMED INVENTOR, I hereby declare that:

My residence, post office address and citizenship are as stated next to my name.

I believe that I am the original, first and sole *(if only one name is listed below)*, or an original, first and joint inventor *(if plural names are listed below)*, of the subject matter which is claimed and for which a patent is sought on the invention entitled:

TITLE: : APPARATUS AND METHOD FOR SPREADING CHANNEL DATA IN CDMA COMMUNICATION SYSTEM USING ORTHOGONAL TRANSMIT DIVERSITY

the specification of which either is attached hereto or indicates an attorney docket no. 678-452 (P9148), or:

[ ] was filed in the U.S. Patent & Trademark Office on ________ and assigned Serial No. ________,

[ ] and *(if applicable)* was amended on ________________ ________________,

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to patentability and to the examination of this application in accordance with Title 37 of the Code of Federal Regulations §1.56. I hereby claim foreign priority benefits under Title 35, U.S. Code §119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT international application which designated at least one country other than the United States, or §119(e) of any United States provisional application(s), listed below and have also identified below any foreign applications for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

			Priority Claimed:
1999-4899	Korea	04/02/1999	Yes [X] No [ ]
(Application Number)	*(Country)*	*(Day/Month/Year filed)*	
			Yes [ ] No [ ]
(Application Number)	*(Country)*	*(Day/Month/Year filed)*	

I hereby claim the benefit under Title 35, U.S. Code, §120, of any United States application(s), or §365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application(s) in the manner provided by the first paragraph of Title 35, U.S. Code, §112, I acknowledge the duty to disclose information material to patentability as defined in Title 37, The Code of Federal Regulations, §1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial Number) *(Filing Date)* *(STATUS: patented, pending, abandoned)*

(Application Serial Number) *(Filing Date)* *(STATUS: patented, pending, abandoned)*

I hereby appoint the following attorneys: **PETER G. DILWORTH**, Reg. No. 26,450; **ROCCO S. BARRESE**, Reg. No. 25,253; **DAVID M. CARTER**, Reg. No. 30,949; **PAUL J. FARRELL**, Reg. No. 33,494; **PETER DELUCA**, Reg. No. 32,978; **JEFFREY S. STEEN**, Reg. No. 32,063, **ADRIAN T. CALDERONE**, Reg. No. 31,746; **GEORGE M. KAPLAN**, Reg. No. 28,375; **JOSEPH W. SCHMIDT**, Reg. No. 36,920; **RAYMOND E. FARRELL**, Reg. No. 34,816; **RUSSELL R. KASSNER**, Reg. No. 36,183; **CHRISTOPHER G. TRAINOR**, Reg. No. 39,517; **GEORGE LIKOUREZOS**, Reg. No. 40,067; **JAMES M. LOEFFLER**, Reg. No. 37,873; **EDWARD C. MEAGHER**, Reg. No. 41,189; **SUSAN L. HESS**, Reg. No. 37,350; **MICHAEL P. DILWORTH**, Reg. No. 37,311; **PETER B. SORELL**, Reg. No. 44,349; and **GLENN D. SMITH**, Reg. No. 42,156, each of them of **DILWORTH & BARRESE**, 333 Earle Ovington Boulevard, Uniondale, New York 11553 to prosecute this application and to transact all business in the U.S. Patent and Trademark Office connected therewith and with any divisional, continuation, continuation-in-part, reissue or re-examination application, with full power of appointment and with full power to substitute an associate attorney or agent, and to receive all patents which may issue thereon, and request that all correspondence be addressed to:

Paul J. Farrell, Esq.
DILWORTH & BARRESE
333 Earle Ovington Boulevard
Uniondale, New York 11553
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I HEREBY DECLARE that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 U.S. Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

FULL NAME OF FIRST OR SOLE INVENTOR: Jae-Yoel KIM Citizenship Korea

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Residence & Post Office Address: Baekdu APT #960-1401, Sanbon 9-danji, Sanbon 2-dong, Kunpo-shi, Kyonggi-do, Korea

FULL NAME OF SECOND JOINT INVENTOR: Seung-Joo MAENG Citizenship Korea

Inventor's signature: Date: Feb. 3, 2000
Residence & Post Office Address: Maehwamaeul, #201-1001, Yatap-dong, Puntang-gu, Songnam-shi, Kyonggi-do, Korea

FULL NAME OF THIRD JOINT INVENTOR: Jae-Min AHN Citizenship Korea

Inventor's signature: Date: Feb. 3, 2000
Residence & Post Office Address: Pureun APT. #109-303, Ilwonpon-dong, Kangnam-gu, Seoul, Korea

FULL NAME OF FOURTH JOINT INVENTOR: Hee-Won KANG Citizenship Korea

Inventor's signature: Date: Feb. 3, 2000
Residence & Post Office Address: 1499, Myonmok 7-dong, Chungnang-gu, Seoul, Korea

FULL NAME OF FIFTH JOINT INVENTOR: Citizenship

Inventor's signature: Date:
Residence & Post Office Address:

FULL NAME OF SIXTH JOINT INVENTOR: Citizenship

Inventor's signature: Date:
Residence & Post Office Address: